INDUSTRIAL SAFETY

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Foreword

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One of the truly constructive factors in America's mobilization of men and materials for a technological war has been the greatly increased emphasis on industrial safety. In time of war it is not merely material resources that are in jeopardy but, most valuable of all, life itself. A life lost in an industrial accident is just as great a loss as a life lost on the battlefield.

More and more engineers, plant executives, and workmen are realizing that the practice of the fundamentals of industrial safety reduces accidents, saves lives, and represents an economic gain of substantial proportion. Training courses carried on by most of the engineering colleges of the country during the past two years under the sponsorship of the Engineering, Science, and Management War Training Program of the United States Office of Education and with the coöperation of the National Committee on the Conservation of Manpower in War Industries have been an important factor in bringing this about. More than fifty thousand key men from industry have been enrolled in such classes. The application of the principles of safety in the nation's war industries, both large and small, has become an important factor in reducing time lost through accidents and in saving lives.

But safety is equally important in time of peace, and no doubt the stimulus of the war safety training programs will carry over into the post-war period. No industrial establishment can afford to ignore the fundamentals of safety in the design of its plant and machinery or in its day-to-day operation. It is to be hoped that engineering college graduates of the future will have a greater appreciation of industrial safety than those of the past have had. No doubt, safety specialists will continue to be an important factor in the larger organizations, but it is equally important that the men who have the responsibility for engineering and management in all industrial enterprises have a knowledge of the fundamentals of industrial safety.

This book, prepared by men with long experience as active workers in industrial safety, presents an excellent analysis of the principles which must be practiced by every industrial organization. It should prove particularly useful as a textbook for safety engineering classes and as a reference book for those responsible for the operation of safety programs. As such, it should perform a very real service in the field of industrial safety.

Preface

The outstanding lesson to be drawn from a study of the progress of safety accomplishment is undoubtedly that the present accident waste is almost wholly needless. This waste—a serious continuing drain on our national resources of human and material values—can be largely eliminated if only we can bring about the application of informed, safety-minded common sense to the day-by-day work in the multitude of establishments that constitute American industry. Obviously a wide dissemination of the knowledge of safety fundamentals is required. If this book aids only a little in spreading this knowledge, it will repay, many times over, the effort entailed in its production.

The editor wishes to express his appreciation to the co-authors who, although already burdened with duties vital to the war program, worked wholeheartedly at considerable personal sacrifice to complete the manuscript. He also wishes to acknowledge with thanks the active part played by Professor V. S. Karabasz of the University of Pennsylvania in initiating the ESMWT courses in industrial safety. His enthusiasm and encouragement led to the writing of this book.

The cartoons in this book were prepared especially for the safety engineering program of Purdue University. Their use as work sheets for regular engineering campus courses and for Engineering, Science, and Management War Training courses has been extremely successful. The authors and the publisher appreciate the courtesy of reproducing these cartoons.

They also appreciate the courtesy of The American Society of Mechanical Engineers in supplying the plates for five diagrams that appear in Chapter XVIII.

The coöperation of the National Safety Council, the Division of Labor Standards, and other agencies and individuals who have graciously furnished data and illustrations or permitted references to their material has proved invaluable.

R. P. B.

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CHAPTER I

Introduction to Safety Engineering

During the early years of the safety movement, safety work was "just a job," and few men had safety jobs. Most of these few had been assigned by their respective managements to take over "safety work" because of a dawning realization that "something should be done about it." Availability of the man was usually the basis for selection; someone who knew the plant pretty well and could be spared from his regular work, such as an almost superannuated foreman, a time clerk, or a chief watchman. Occasionally, however, a somewhat idealistic member of the supervisory or technical staff caught the vision of a real need and a great opportunity for service to his fellow men. Saddened by the sufferings of those maimed at their work, he became filled with a desire to "do something about it." He got the safety job on such a basis. Such men became the pioneers of safety; the men whose courage, determination, and hard work laid the foundation on which great progress has been made. Many of these pioneers have passed on; a few are still with us. Other men—a steadily increasing number—have caught the vision, and the safety movement goes on and grows as it advances. There is need for still more men like these. Needed even more, everywhere, by everyone, is an understanding at least of the simple fundamentals—and they are simple—of the means by which accidents can be prevented. This text has been prepared as a part of the effort to meet that need.

The accident problem

Each year more than 100,000 Americans are killed by accident and some 9,000,000 more are injured. The money cost of these accidents is not accurately determinable, but it is conservatively estimated to be in excess of four billions of dollars per year.

Occupational injuries

Industry contributes a large part of this tremendous total of death and injury. During 1941 approximately 19,200[1] workers lost

[1] U. S. Bureau of Labor Statistics, Serial R-1481, Government Printing Office, Washington, D. C.

their lives from on-the-job injury. Approximately 100,600 others suffered various permanent disabilities such as the loss of an eye, an amputation, the partial loss of a finger, or a stiffened finger joint. Some 2,060,400 more were injured to an extent such that each was unable to work for at least one day. The total working time lost by these injured workers through these on-the-job injuries amounted to approximately 42,000,000 man days. The money cost is estimated to have been in excess of $850,000,000.[2]

But this is not the complete picture of the accident problem in industry. During 1941, off-the-job accidents are estimated to have accounted for 32,000 additional worker fatalities and 2,400,000 nonfatal injuries.

Losses due to accidents

When industrial workers are killed or injured through accidents, no one gains—everybody loses. Employers, society, injured workers and members of their families all suffer losses that can never be replaced. Even those injured workers covered by workmen's compensation acts or by accident insurance policies receive substantially less in benefit payments than their wages would come to; those not so protected receive nothing while disabled, and they have medical expenses besides. Employers lose the services of trained workers. Society finally pays the full cost through the prices of goods and services, taxes, the costs of various forms of charity; through the lessened effectiveness of permanently injured workers; and last, but certainly not least, through the many serious results that flow from reduced family income.

This continuing stream of injuries to industrial workers constitutes a serious national problem. Such injuries affect the welfare of industrial organizations and the well-being of all our people. They waste our human and material resources at a rate that is a serious and ever-increasing drain on our national economy. Their destruction of human values is enormous. Anything approaching an accurate summation of the grand total that this continuing waste has mounted to is impossible; but it is certainly conservative to say that the loss of life from industrial accidents has during the lifetime of the nation totaled many times that occasioned by all the wars, domestic and foreign, in which the nation has been engaged.

The loss of productive time also bulks large. The actual loss of working time suffered during 1941 by injured workers may be approximated as follows:

[2] National Safety Council. *Accident Facts.* 1942 Edition.

2,060,200 temporary disabilities	34,035,000 man days
100,600 permanent partial disabilities	8,048,000 man days
Total for nonfatal injuries	42,083,000 man days

The time loss, due to the 19,200 fatalities, that should be charged to 1941 is a debatable question. If we assume an average of half a work year or 1,000 hours for each, we get

19,200 fatalities	2,400,000 man days
Total for on-the-job injuries	44,483,000 man days

By similar figuring, we get for the off-the-job injuries to workers (32,000 fatal, 2,400,000 nonfatal) a total of 52,000,000 man days, which, added in, gives a grand total of working time lost, 96,483,000 man days. This is approximately equivalent to an army of over one third of a million workers sitting idle throughout the entire year. Such a needless loss of productive capacity is a serious problem even in peacetime, but in wartime the prevention of accidents becomes a patriotic duty of every man, woman, and child who is interested in a rapid and decisive victory.

The loss of working time involved in worker injuries should not be confused with loss of production. It should be obvious that every death or serious on-the-job injury interrupts or adversely affects production. But the time the injured worker loses from work is not a measure of lost production. An accident that yields only a minor injury or none at all may result in a serious loss of production. On the other hand, a substitute worker may be quickly available to step into the injured one's place, and thus production may be kept flowing with little loss.

Accident record has improved

Over the years, there has been a considerable improvement in our industrial accident record. It is not possible to say just how much gain has been made, however, because, until recent years, accident data were so incomplete and inadequate that the most authoritative figures can be regarded only as fairly good estimates. Even today there undoubtedly is a moderate margin of error in the figures used. All totals given are based on incomplete data supplemented by estimates for the proportion of employment for which accident records are not available. This fact presumably accounts for the variance in the totals given by the two leading authorities, the United States Bureau of Labor Statistics and the National Safety Council. The Council estimates for 1941 are 18,000 deaths, 70,000 permanent disabilities, and 1,530,000 temporary disabilities. The Bureau of Labor Statistics estimates are based on a much larger coverage than are those of the Council and

are strengthened by a method of sampling designed to reduce the error to a minimum. Therefore we have preferred to use the Bureau's figures for the overall totals. However, Council data based solely on the reports of member firms and others who report directly to it are undoubtedly highly accurate.

The earliest reasonably acceptable estimate of the annual industrial death toll is for 1913. The figure given then was 25,000.[3] Probably the trend was upward through the war years, followed by a fairly steady decline to a low of 14,500[4] in 1933. Since then the figure has fluctuated in general accord with the ebb and flow of industrial activity. When the great increase in employment is taken into account (estimated at some 40 per cent since 1913), it appears reasonable to conclude that the 1941 totals, huge as they are, would have been not far from twice as great had American industry continued to operate with no more attention to safety than was usual 30 years ago.

The annual reports issued by the National Safety Council on the accident experience of its several thousand member firms not only give considerable support to the above conclusion but also add valuable information as to where the gains have been made. These reports show a reduction of 67 per cent in the overall frequency rate[5] for Council membership during the period 1926–41, inclusive. Some industry divisions showed reductions up to 80 per cent. In some instances (notably Portland cement), practically the entire industry reports to the Council, hence in such instances Council averages may be taken as applicable to the entire industry.

Large firms make greatest improvement

A study of available data reveals the fact that, as a group, the large firms have achieved a much better improvement in their accident frequency rates than have the smaller firms. This is particularly true of the manufacturing and the public utility industries, but their good records have not reduced the national totals as much as might be expected. There are two reasons for this: first, the number of large manufacturing firms employing more than 500 workers each is comparatively small (only 2,300—about 1.3 per cent—of the total of 184,000 manufacturing concerns in the United States[6]); and second, only about 35 per cent of all workers in manufacturing are employed by these large firms.

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[3] Bulletin 157, "Industrial Accident Statistics," Frederick L. Hoffman. Government Printing Office. 1915.

[4] National Safety Council.

[5] Frequency rate is the number of disabling injuries per million man hours worked.

[6] U. S. Department of Commerce, "Census of Manufacturers," 1939.

Several entire industries make improvement

Several entire industries such as steel, automobile, cement, public utility, petroleum, and transportation have achieved outstanding improvement. Mining has shown great improvement but still has far to go, as does the construction industry. Logging and lumbering show the highest frequency rate among major industrial classifications, with improvement if any not discernible except for a few firms. It is interesting to note that in the industries showing major improvement, the percentage of large firms as compared with small firms is much higher than in industry in general.

The statistical evidence supporting the above statement is not in a sufficiently complete form to permit accurate comparisons, but the evidence that small firms in general have higher injury rates than very large firms is conclusive. The membership of the Council consists overwhelmingly of large firms. The Council average frequency rate for 1941 was 15.39. If the total of industrial deaths and injuries already given of 2,180,200 in 1941 is applied to the estimated total average employment of 49,640,000[7] for that year, the overall frequency rate works out to be approximately 22. Since this includes many millions of workers in such low-hazard employment as office and professional work, domestic service, and merchandising, it is obvious that productive industry as a whole must average higher than the overall figure.

State factory inspection departments uniformly report that they find the accident records of larger firms generally much better than those of small establishments and undertakings.

Data from insurance sources giving the combined experience of large numbers of small firms, selected solely on the basis of size, give a similar picture. One such study, covering over 500 firms employing less than 100 employees each, yielded an average frequency rate of 45.4 for a 5-year period, 1936–40 inclusive.

The reasons for most of the gain being made by the larger firms are fairly evident. The large firms have good cost systems and readily become conscious of accident costs and of the savings to be made by reducing them; they maintain staffs of competent technicians, and they generally take advantage of the services of National Safety Council and other safety agencies. Probably the employment of full-time safety personnel is the most important factor involved. This brings up the question as to the size of firm that will find it profitable to employ a full-time safety engineer. No specific answer can be given, for employment of such a person

[7] U. S. Bureau of Labor Statistics.

will depend chiefly on the nature of the work. The insurance premium will furnish a fairly good rough measure. For the more hazardous work—construction, mining, and so on—the firm might be composed of as few as 200 or 300 workmen; for woodworking or metal working, of a considerably larger force; for low-hazard industries—tobacco or textile—of perhaps 1,000 or more. Undoubtedly, as managements in general become more fully informed of the manifold benefits that come from the elimination of accidents, the employment of full-time safety personnel will increase. For firms too small to have a full-time safety engineer, the practical step is to assign a key man to safety work on a part-time basis with provision for his adequate training in safety techniques and with responsibility, authority, and method of functioning definitely set forth and understood by all.

Small firms and small activities—a major problem

It thus becomes obvious that one of the big problems confronting the safety movement is the failure of small firms to prevent employee accidents. The importance of this problem is emphasized by the fact that small firms employ such a large majority of our industrial workers. The problem becomes even more apparent when we study the injury totals of the major industry groups. For 1941 these were:[8]

Agriculture	270,400
Construction	495,500
Manufacturing	452,700
Mining and quarrying	97,100
Public utilities	21,000
Railroads	48,200
Trade (wholesale and retail)	297,100
Miscellaneous transportation	130,300
Services, government and miscellaneous industries	367,900
Total	2,180,200

Agriculture consists of small activities; construction also, for the most part; trade and services, overwhelmingly so. All others of the above industry groups are composed of many small firms. Obviously, if large firms were to eliminate accidents entirely, the large majority of the above injury total would still remain. Therefore, if further major reduction in the annual industrial accident toll is to be gained, the "know how" and practice of safety must be broadly extended throughout "small" industry.

It is apparent that whatever attempts have been made to improve the safety performance of small establishments in general

[8] Serial R-1481, U. S. Bureau of Labor Statistics.

have failed. Probably the chief reason for this failure is the sheer magnitude of the job. There are so many of the small firms and small activities that the undertaking actually involves changing to an important extent the viewpoint and actions of a very large segment of our population. Certainly the advantages of preventing accidents are relatively as important to the small firms as to the great corporations. The same arguments should apply and it should be possible to promise similarly worth-while benefits. The simple answer is that these arguments have actually been presented properly to only a relatively few small managements.

Safety was not easily sold to big management. Most executives of large firms acquired the idea slowly through glimpses of accident wastage in terms of an occasional item of direct expense, spoilage, damage to machinery, interference with production, and so on. This wastage gradually aroused the executive's interest enough to cause him to "hire a safety man" or to direct some member of his staff to "get busy on it." Usually the person thus selected found, after a period of trial and error and self-education, that the further education of his management was a major part of his job. This is still too often true, for the sum total of experience to date shows clearly that the one factor absolutely essential to really first-rate safety performance is management's determination to get it. The problem thus is really one of getting each management to realize the benefits of preventing accidents and to take the necessary steps to secure the desired result. The facts must be brought to each management directly and in convincing detail.

It is obvious that the National Safety Council cannot do much in this direction with small establishments in general; it has neither the funds nor the staff to go out and carry the facts to the multitude that its number runs to. Community Councils have sold the idea to a few and will continue to do this increasingly; but it does not seem likely that the number reached by this means will ever bulk large.

The compensation insurance underwriters have done much and will continue to do more, but the amount of personal service that the insurance company can give to an individual risk is necessarily governed by the amount of premium involved. The less the premium, the smaller the expenditure that can be made to service the risk.

The most promising attack on the problem seems to be that made by the various states through the agencies administering their labor laws, chiefly the factory inspection departments. In past years these were set up solely (or almost solely) as enforcement

agencies. Some of them still function primarily in that capacity. However, the trend is strongly toward the development of safety-inspection services staffed by men competent to carry the "know how" of safety to all establishments within their jurisdiction. Safety laws, rules, and regulations are necessary to set a minimum level for safety, but it is increasingly realized that these are at best merely foundational. The structure of safety, however, must be erected on this foundation.

Most of the heavily industrialized states have reasonably satisfactory minimum safety standards, and several other states are developing them. A few of the state inspection services are already rendering an excellent service of prevention; others are improving. Means are being developed whereby the highly valuable information contained in the flow of accident reports to compensation commissions is made directly and promptly available to the inspection services. Much more needs to be done in this respect, however.

If safety councils, insurance carriers, employers' associations, community groups, organized labor, and other agencies interested in the problem of reducing the accident wastage will expand and intensify their efforts to promote widespread knowledge of and interest in preventive methods, it will help greatly. The more who join the effort, the larger the gain will be. A few pioneers of safety started the safety movement; thousands are now actively engaged in it; tomorrow it must be a multitude.

The reasons for small firms not having done a better job seem to be chiefly:

1. Small firms cannot afford to employ full-time safety engineers.
2. All too frequently the responsibility for safety is not given to anyone, even as a part-time job.
3. If the responsibility for safety is assigned to someone, that person may have insufficient authority to secure results.
4. If the responsibility is retained by the president of the firm or assigned to some other top-ranking executive, that person may already be so overloaded with other duties that he has no time to devote to safety.
5. The average small firm does not maintain a running record of accidents, of accident rates, or of accident costs.
6. Even a very high accident rate will produce accidents so infrequently in a small group that its executives are not likely to be impressed thereby with the seriousness of the problem.

7. Small firms rarely join such organizations as the National Safety Council, nor do their representatives attend safety meetings to an appreciable extent.

8. Small-firm executives usually are reluctant to make expenditures from which they do not see definite and prompt returns.

9. The number of small firms is so great that the job of carrying the "gospel of safety" to them is far beyond the capacity of the promotion method of attack that, under the leadership of the National Safety Council, has proved so effective with large firms.

10. On the whole, these factors can probably best be summarized in this one statement: the average small firm does not do good work in accident prevention because the chief executive does not devote to the accident problem the relatively small amount of time and money that are required to secure the desired results.

Safety engineering not an exact science

It is only natural for beginners in safety engineering to ask for an ideal pattern of procedure which they can follow and which will assure immediate success. Likewise, it is only natural that they should be keenly disappointed when they learn that there is no such pattern. Safety engineering is a new profession, and the technique of safety is a relatively new technique that has been evolved by the trial and error method. It is so new, in fact, that many of its component activities have not yet become standardized. Perhaps they never will be standardized into an inflexible formula. Hundreds of safety engineers have achieved highly satisfactory accident records, but probably no two have employed methods that were exactly alike, even though they may have been working under conditions that seemed almost identical. Unfortunately, safety engineering is not an exact science like mathematics, chemistry, and physics. Accidents are eliminated by building safety into every detail of plant and equipment and by incorporating it into every activity carried on in a given establishment.

Major lessons from experience to date

On the other hand, when one appraises the results that have been achieved in the past from certain activities and methods, one cannot fail to formulate in his own mind a number of general conclusions that he can use as the basis for his future thinking and planning. In other words, the lessons learned from the past experience of hundreds of successful safety engineers and safety-minded industrial executives can be invaluable. These lessons are

clearly understood and intelligently adapted. The following is a brief outline of some of the more important conclusions:

1. Accidents can be prevented.
2. To prevent accidents is good ethics and financially profitable.
3. The expenditures required are relatively small.
4. The technique of prevention is not difficult. It is primarily a matter of the unremitting application of common sense.
5. Accidents are caused, they don't simply happen.
6. It is important to discover the cause (or causes) of each accident, then to eliminate those causes so that similar accidents will not recur.
7. It is even more important to discover and eliminate accident hazards *before* they become accident causes.
8. Causes of accidents are more important than causes of injuries.
9. Practically every industrial operation, no matter how simple, presents certain hazards that can be discovered and eliminated.
10. In general, the great majority of accidents in all firms are due to similar causes regardless of size of the establishment or type of industry.
11. Safety in any firm is not a one-man job. Accidents cannot be eliminated unless every man in the organization from the top executive down to the most lowly laborer accepts his share of the responsibility.
12. Many of the methods used to control quantity, quality, and cost of production can be used with equal effectiveness to control accidents.
13. The safety engineer's job is two-fold: first, to formulate and direct the safety program; second, to influence everyone in the firm to do his part in preventing accidents.
14. It is not necessary to employ a full-time safety engineer, especially in the small firm, if some capable man will devote a part of his time to this two-fold job and if he will do it effectively.

These and many other related points will be discussed in further detail in succeeding chapters.

REVIEW

1. What was the approximate total of occupational fatalities, permanent, partial, and temporary total disabilities in 1941?

2. What was the approximate total loss of working time they occasioned?

3. Why does not the loss of working time afford a good measure of the production loss?

4. How does the 1941 total of occupational accidents compare with that of, say, three decades earlier?

5. Where has most of the gain been made?

6. What major problem must be solved if the greater part of the accident toll is to be eliminated?

7. Give what appeals to you as the five chief reasons why small firms are laggard in accident prevention.

8. Give what appeals to you as the five most important lessons learned from safety experience to date.

CHAPTER II

Brief History of Industrial Safety in America

The handicraft era

Before the year 1800, there was no industrial system in America and there were no large towns as we know them today. Most families lived on small farms where they made their own clothing and raised enough food for their own use. It was not necessary to have much money, because each family was practically self-sufficient and the things one family did not make or raise were secured by trading with neighbors.

The Industrial Revolution

Soon after 1800, however, the effects of the Industrial Revolution that had started in England about a hundred years earlier began to be evidenced in America. Steam engines were imported into Massachusetts and mills were constructed to manufacture cotton textiles. Workers were recruited from near-by farms, most of them women and young children. Many of the children were between the ages of six and ten years.

The introduction of Eli Whitney's cotton gin early in the 1800's made a great contribution to the Industrial Revolution in America; but the transformation of the United States into an industrial country took place largely after the Civil War.

Early working conditions

For many years, working conditions in industry were deplorable. No attention at all was paid to the safety, health, and welfare of the workers. Light, ventilation, and sanitation were not even considered. Each person worked from twelve to fourteen hours a day for six days a week. Deaths were frequent, and serious injuries were accepted by workers and employers alike as a necessary by-product of each establishment, a price that had to be paid for industrial progress. Most employers believed that they owed no obligation whatsoever to an injured worker; they felt they were doing their whole duty if they gave a job as watchman to a man who had lost an arm or a leg, or if they made a reasonably generous

contribution to the funeral expenses of a worker who was killed in the plant.

Early legislation

Since Massachusetts was the leading state from an industrial point of view, it is not surprising that it became the leader in industrial legislation. This leadership was due in large part to the humanitarian and social arguments voiced by the clergy and the press. In 1867, this state passed a law providing for the services of factory inspectors, and two years later it created the first bureau of labor statistics to study, among other things, the accident problem. Shortly after this, the same state established the ten-hour maximum working day for women. Then in 1877 the Massachusetts legislature voted to compel employers to safeguard hazardous machinery.

In 1885 Alabama passed an Employers' Liability Law, and Massachusetts did likewise in 1887. Although these laws were a long step in advance, since they made the employer liable for damages when workers were injured, they contained numerous loopholes. Chief of these were the three so-called common law defenses: contributory negligence, assumption of risk, and negligence of a fellow-worker. Since at least one of these was applicable, to some extent, in nearly every case of work-connected injury, relatively few claimants were successful. Also, since lawsuits are expensive, many did not press their claims. Those who did and were successful usually had to pay out a heavy proportion of their awards to meet the costs of the suit. Altogether, the financial burden on the employer was not sufficient to spur him on to prevent worker injuries.

Safety promoted by insurance companies

As other states passed similar laws, insurance companies stepped into the picture by providing protection to employers against the heavy unforeseeable costs that might result from injuries to their workers. Engineers were employed to inspect insured establishments primarily to evaluate the accident hazards to which the workers were exposed so that the necessary premium rates might be assigned. While studying operations in all sorts of industries and the conditions that caused accidents, these engineers learned various ways of reducing or eliminating many of the hazards; so it was not long until their services in the field of accident prevention became at least as valuable as their work of inspection.

Industrial leadership

Safety leadership among industrialists was woefully weak at first. A changing attitude was evidenced, however, when in 1892 a safety department was organized in the Joliet Works of the Illinois Steel Company. Incidentally, the first safety order issued called for the inspection of all engine fly wheels. Because of this early definite start and the fact that its program spread to many other mills, this mill has often been referred to as "the birthplace of the American industrial accident-prevention movement."

Workmen's compensation laws

Meanwhile, dissatisfaction with the practical working of employer liability laws grew. Organized labor, the clergy, and the press campaigned vigorously for corrective action. This action came in the form of workmen's compensation legislation, whose basic principle is to require the employer to pay the injured worker's medical and hospital expenses plus compensation intended to furnish him (and his dependents) at least a minimum subsistence during his period of disability. The question of fault is eliminated, the only requirement being that the injury shall arise out of the employment. Also, under proper administration, the worker who has a legitimate claim need be put to no expense to secure the compensation due him. These laws, through making worker injuries immediately and directly expensive to employers, have done more to promote interest in safety than have all other influences put together.

The first compensation law was enacted by Congress in 1908, but the benefits were very meager and they were limited to certain special classes of federal workers. The oldest law of its kind still in force in the United States was passed by New Jersey in 1911. Other states rapidly followed this lead: seven in 1911, three in 1912, eleven in 1913, two in 1914, and ten in 1915. In 1943 workmen's compensation laws were in force in all states except Mississippi.

As workers came generally to understand their rights under these laws, and as enforcement grew in effectiveness, the number of claims increased rapidly, and the total cost to employers mounted to such substantial figures that some executives began to search for methods of preventing accidents, for it seemed likely that prevention would cost less than compensation.

National Safety Council

In 1912 a small group of engineers met in Milwaukee under the auspices of the Association of Iron and Steel Electrical Engineers

to exchange ideas on such subjects as the costs of accidents, their causes, and their prevention. These early enthusiasts represented insurance companies, industrial corporations, departments of state and federal government, and other interested groups. At this meeting it was agreed to organize a larger convention, which convened the following year in New York City. Thus, in 1913, was perfected the organization of the National Council for Industrial Safety, which for two years confined its activities to the industrial accident problem. In 1915 the name of the organization was changed to National Safety Council, and the scope of activities was broadened to include the prevention of all accidents, regardless of location or activity, on the streets and highways, among school children, in the homes, and so on. Under the Council's leadership, interest in safety is continuously increasing. How much of the phenomenal upsurge of interest evidenced by 1943 was due to a general realization of the need to eliminate waste of all kinds and how much was due to the Council cannot be estimated, but certainly this organization deserves a very large share of the credit.

The Council publishes six monthly magazines: *National Safety News* (for industrialists), *Public Safety, The Industrial Supervisor, The Safe Worker, The Safe Driver,* and *Safety Education* (for school teachers).

Other literature includes a series of semitechnical publications such as safe practices pamphlets, health practices pamphlets, industrial data sheets, accident facts, and the annual safety congress transactions. Then there are safety posters, rule books, safety calendars, and so on.

The Council's library is the most comprehensive collection of safety information in existence, and staff engineers gladly answer inquiries concerning all phases of accident prevention and allied subjects. However, since the income of the Council is derived primarily from industrial firms whose annual dues vary in accordance with the number of workers employed, the amount of service that can be given to nonmembers individually must of necessity be limited.

Community safety councils

Soon after the organization of the Council, it became apparent that the prevention of accidents on a large scale in any individual community required a local organization to augment the efforts of the parent body. Therefore, in 1917, the first paid manager of a community safety council was installed in the city of Pittsburgh to secure the active support and coöperation of city officials, school

authorities, industrialists, parent-teacher associations, newspapers, the clergy, clubs, insurance representatives, and other groups in carrying out a comprehensive accident-prevention program. Within a few years, the number of community safety councils has increased to more than sixty, and it does not seem improbable that soon similar organizations will be perfected in all of the country's larger cities.

The following is a partial list of activities carried on by various community safety councils:

Safety meetings for top-management representatives of industry.
Safety meetings for safety engineers.
Safety meetings for foremen and industrial supervisors.
Safety rallies for industrial workers.
Safety meetings for motor vehicle fleet supervisors.
Safety meetings for motor vehicle drivers.
Regional or state-wide safety conferences held annually.
Safety meetings for watchmen.
Fleet safety contests.
Industrial safety contests.
Publicity through the press and radio.
Publication and distribution of accident-prevention leaflets, booklets, and other literature.
Organization of school-boy safety patrols.
Provision of safety speakers for all sorts of occasions.

Other organizations rendering safety service

Literally hundreds of other organizations provide specialized safety service in more or less limited fields. The following are a few:

American Society of Safety Engineers.
Associated General Contractors of America.
American Standards Association.
American Museum of Safety.
American Public Health Association.
American Mutual Alliance.
American Gas Association.
American Transit Association.
American Petroleum Institute.
American Railway Association.
Automobile Manufacturers Association.
American Industrial Hygiene Association.
Fire Mutuals.
International Association of Industrial Accident Boards and Commissions.
National Conservation Bureau.
National Bureau of Standards.
National Electric Light Association.
National Fire Protection Association.
Portland Cement Association.

State Safety Departments.
United States Department of Labor.
United States Bureau of Mines.
United States Public Health Service.
Underwriters Laboratories, Inc.

Space limitations permit but a brief outline of the accident-prevention functions of only several of the organizations listed above.

United States Bureau of Mines, Washington, D. C. This bureau was organized in 1910 in the Department of the Interior. One of its major functions is to study the causes of accidents and ill health among miners and to promote the application of preventive measures. Its work has been and continues to be outstanding in its field. A very large part of the reduction in the accident rate in the mining industry is certainly to be credited to the activities of the Bureau. Its most spectacular work has been that connected with coal mine explosions. It developed rescue methods and provided trained rescue crews with the specialized equipment necessary. It discovered the causes of mine explosions and proved them preventable. Its first-aid courses have had a very important influence in promoting interest in safety. Recently Congress added the duty of setting up and maintaining a coal mine inspection service, designed to be informational and preventive, in close coöperation with the mine-inspection services of the various states.

Bureau of Labor Statistics, United States Department of Labor, Washington, D. C. Organized in 1913 in the Department of Labor, this bureau among other things collects, tabulates, and disseminates statistical information about industrial accidents and health. It issues annual reports on industrial injuries, giving estimated national totals and breakdowns by industry. It supplements these with reports on specific industries.

National Bureau of Standards, Washington, D. C. One function of this bureau, organized in 1910 in the Department of the Interior, is to create safety standards for various materials and equipment and to formulate testing methods for determining their safety. The total volume of its accomplishment in the fire-prevention and accident-prevention fields bulks large. It works very closely with the American Standards Association, itself sponsoring many of the codes.

Division of Labor Standards, United States Department of Labor, Washington, D. C. The objectives of this division, created in 1934, are to formulate labor standards in labor legislation and labor law administration, and also to promote the improvement of working conditions. Its safety activities as a part of this general

purpose include coöperating in the development and promotion of "American Standard" safety codes through ASA procedure, furnishing safety and health-consulting services to labor administrative agencies and labor organizations, aiding states (which request it) to train and improve the competency of their safety-inspection personnel, and in general coöperating in the movement to reduce the toll of industrial injuries. The Division played a major part in the formation of the Federal Interdepartmental Safety Council formed to promote safety in federal employment. In 1940 the Division organized the Committee for the Conservation of Manpower in the Defense (later War) Industries, whose basic idea is to make available to plants lacking adequately trained safety personnel a safety consultant and advisory service through the part-time use of safety engineers loaned for the purpose by their employers. A major activity of this committee and of the Division has come to be the promotion of safety training under the Engineering, Science, Management War Training program. A large part of the course material was developed by the Division's staff.

State safety services

Every state has created some department or bureau that is charged with at least partial responsibility for the safety of the wage earners employed in that state. The names of these organizations vary in different states—for example, Department of Labor and Industry, Industrial Commission, Department of Labor, and so on. The first organization of this type to be created was the Massachusetts Department of Factory Inspection in the year 1867.

As previously pointed out, such agencies were set up to enforce laws aimed at the correction of bad conditions or abuses connected with employment. The same campaign that led to the widespread passage of workmen's compensation acts also generally brought companion legislation requiring the safeguarding of hazardous machinery and equipment. The thought was to secure correction through laws enforced by inspectors armed with police power. Penalty for noncompliance is generally fine or imprisonment or both. In many states the nonconforming employer may be forbidden to operate the machine or equipment in question, or even the entire plant, if the hazard is general, until the hazardous condition has been corrected.

The present strong trend to substitute education (the sales approach) for enforcement rests upon the basic fact that if management and workers alike realized fully that accidents do in truth constitute a serious preventable loss to each of them, they would jointly take the action necessary for practical elimination.

Such understanding is not to be had by mere enforcement. It can be developed only through persistent and painstaking presentation of the facts to everyone concerned. Since, however, management has the responsibility for everything that goes on in its establishments and possesses the means of control, the promoter of safety (under whatever name) must deal primarily with management.

The above statement should not be interpreted as advocacy of the reduction or elimination of enforcement authority or of reasonable minimum standards having the force of law. There are always a few managements that will not comply with even minimum standards of proper practice unless they are forced to, and failure to secure at least the reasonable compliance of even a small minority will jeopardize or perhaps nullify the entire program for improvement. Furthermore, the mere fact that the safety representative is backed by the authority of the state insures at least a reasonable hearing for his arguments. If he really knows his subject and can present it effectively, he will rarely have to exercise his authority.

The growing appreciation of the need for a high standard of competence of the safety-inspection services furnished by the respective states offers great hope in the struggle to reduce the tremendous waste that occupational accidents create. Unfortunately, whenever any new governmental agency is proposed, the battle to make it a means of paying political debts commences. However, the fight to place state safety services on a basis of competency is winning. In a number of states such departments have been removed from political control and are rendering excellent service. Many other states are moving in this direction. Whenever and wherever organized employers and organized labor make common cause to secure competent and adequate safety-inspection service, they can have it. Until they do, they are not likely to get it. When we have, throughout the nation, safety inspectional and promotional services adequately staffed by competent, well-trained personnel, we can expect major reduction in the accident waste. Until we have such services, we can expect little improvement except that occasioned by drops in industrial activity. If this statement is accepted as true, the tremendous responsibility of state safety officials becomes obvious, particularly in securing the needed improvement in the safety performance of the multitude of small establishments and small undertakings of all kinds. The duty of employers, labor, and the interested public to support the efforts of such officials is no less definite and should be equally obvious.

Safety-training courses

As indicated in the brief description of safety council activities, the teaching of safety is a major activity. However, this teaching has been aimed mainly at in-plant employee training and toward the promotion of safety-mindedness among grade and high-school children. It has not taken the form of formal courses on industrial accident prevention at the collegiate level. Efforts to get such courses started have had to face the lack of knowledge of the subject by college staffs, the lack of suitable texts, and the uncertainty as to whether or not classes would be filled. These difficulties are being overcome, however, and a promising beginning has been made as a direct result of the war emergency. In 1940 the demand for technically trained personnel led to the initiation of the nation-wide program of engineering, science, management, defense training known as ESMDT courses. These were federally financed, administered by the United States Office of Education, and given by the colleges. The first course on industrial safety under this program was one of 150 hours' length offered by the University of Pennsylvania with the coöperation of the Philadelphia Safety Council, the Philadelphia Chapter of the American Society of Safety Engineers, and the Division of Labor Standards. This course was so successful that a 96-hour course based on it was offered on a nation-wide basis. By January 1, 1943, over 20,000 key industrial persons had completed the course or its approximate equivalent and provision had been made for an approximate doubling of the enrollment.

The growing realization of the fact that our human power is all too small for the demands war places upon it has greatly increased interest in accident prevention. Until the war is won, every effort must be exerted to conserve our human resources; cost is for the time being secondary. However, when peace returns, it will still be vitally important to conserve our resources, both human and economic, by eliminating, as far as possible, the tremendous accident wastage.

It is obvious that since widespread knowledge of good safety practice is necessary, at least the fundamentals of accident prevention should be taught widely. With the ESMDT safety courses as a start, it seems reasonable to predict that the inclusion of safety in collegiate curricula generally will follow. In January, 1943, two methods were under discussion, namely, offering courses leading to the degree "Safety Engineer," or including in each engineering subject taught the part of safety appropriate to the subject in question. For example, machine design would include design and

guarding to secure the maximum in safety for those who work with, on, or about a given machine. For those students who expect to make accident prevention their lifework, a senior year elective designed to supplement this subject-by-subject treatment of safety would be offered. Since the chief need is that every graduate engineer be at least safety-minded, the second method would seem to be much the better; though should a demand for a special course leading to a degree in safety develop, it will undoubtedly be offered.

REVIEW

1. What state passed the first employers liability law? How? When?

2. What is meant by employers' liability law?

3. Why were such laws not satisfactory?

4. What were the three common law defenses?

5. What is the basic principle of workmen's compensation legislation?

6. What state still has no workmen's compensation law?

7. Describe the start of the National Safety Council.

8. What is the scope of its activities?

9. Why are community safety councils necessary?

10. Why are safety services furnished by the various states advocated so strongly?

11. Why is it important that industrial safety be taught in the colleges?

CHAPTER III

Accident Costs

It has frequently been said, "When a person is killed by accident, no one gains—except the undertaker."

As indicated in Chapter I, accidents to workers are costly, not only to the employer, but also to the injured man, his family, and to society as a whole. Explanatory detail is given in succeeding paragraphs.

Cost to employer

Conservative estimates show that on the average each lost-time injury in industrial employment costs the employer approximately $950.00. This amount may seem unbelievably high, but let us analyze various data to see how we arrive at such a figure.

We will go back to the year 1940 for our basis because data necessary to our calculation happen to be available for that year. While some variation could be expected, if any other year were chosen for the analysis, such difference would not be large enough to be of consequence.

According to the United States Bureau of Labor Statistics, the industrial-injury toll for 1940 was 18,100 deaths, 80,600 permanent disabilities, and 1,782,000 temporary disabilities—a total of 1,889,700.[1] Compensation payments for that year totaled $257,000,000.[2] Medical expenses amounted to some $80,000,000.[3] In addition, the overhead cost of insurance came to some $110,000,000.[3]

It has become customary in insurance circles and among safety men to refer to compensation payments and medical expense as "direct cost." All other accident costs are spoken of as indirect costs. If we apply the above totals of "direct" cost for 1940 to the total of injuries for that year, we get an average figure for the direct cost per injury of $178. Careful analyses show that on the average the indirect cost (to the employer) of lost-time injuries is at least four times the direct cost. This brings the figure per injury

[1] U. S. Bureau of Labor Statistics, Serial R.1353, Government Printing Office.
[2] Social Security Bulletin, Vol. V, No. 1, January, 1942.
[3] National Safety Council, *Accident Facts*, 1941 edition.

to $890. In addition, the overhead cost of compensation insurance (obviously borne by employers as a class) was given for 1940 as $110,000,000.[4] This adds another $58, bringing the average cost to the employer to $948 per injury.

The above figure is quite evidently low rather than high, because a substantial proportion of the injury total is suffered by workers not under any form of compensation insurance. Farm and domestic labor is almost wholly exempted, as is also a considerable proportion of such other groups as retail trade and many services and miscellaneous industries. While in the main the injury rate is not high in such employment, the number of workers is so large that their injury total is very considerable; and if a reasonable allowance were made for this in the injury total used in the above calculation, the figure of average cost arrived at per injury would be increased materially.

While there is wide variation among the various states in the compensation payments for identical injuries, the reports of the compensation commissions do, in general, support the above estimate of average direct cost. In addition to the variations in the provisions of the compensation acts, however, the variations in accounting procedures make satisfactory calculation of the average compensation payments for the individual states practically impossible. The National Safety Council reaches a similar figure by a different route; it gives for 1941 the following data:[5]

Wage loss (to injured employees)	$560,000,000+
Medical expense	90,000,000+
Overhead cost of insurance	190,000,000+
Total	$850,000,000

Of this, the direct cost, according to the Council, comes to about $425,000,000 because compensation payments provide for the payment of only a portion of the wage loss to injured workers. If we apply the 4-to-1 ratio, the total cost to employers becomes $2,125,000,000. Applied to the total of 2,180,200 injuries for 1941, the cost per injury comes to approximately $1,000, which agrees with the above figure of $948 sufficiently to lend it support.

What is the indirect cost?

The indirect cost of industrial accidents is detailed by Heinrich[6] as follows:

[4] National Safety Council, Accident Facts, 1941 edition.

[5] *Accident Facts*, 1942 edition.

[6] Heinrich, H. W., *Industrial Accident Prevention*, McGraw-Hill, N. Y., 1941.

I. Cost of lost time of injured employee.
II. Cost of time lost by other employees who stop work:
  a. Out of curiosity.
  b. Out of sympathy.
  c. To assist injured employee.
  d. For other reasons.
III. Cost of time lost by foreman, supervisors, or other executives as follows:
  a. Assisting injured employee.
  b. Investigating the cause of the accident.
  c. Arranging for the injured employee's production to be continued by some other worker.
  d. Selecting, training, or breaking in a new worker to replace the injured man.
  e. Preparing state accident reports, or attending hearings before state officials.
IV. Cost of time spent on the case by first-aid attendant and hospital department staff, when not paid for by the insurance carrier.
V. Cost due to damage to the machine, tools, or other property, or to the spoilage of material.
VI. Incidental cost due to interference with production, failure to fill orders on time, loss of bonuses, payment of forfeits, and other similar causes.
VII. Cost to employer under employee welfare and benefit systems.
VIII. Cost to employer in continuing the wages of the injured worker in full, after his return—even though the services of the worker (who is not yet fully recovered) may for a time be worth only about half of their normal value.
IX. Cost due to the loss of profit on the injured worker's productivity and on idle machines.
X. Cost of subsequent injuries that occur in consequence of the excitement or weakened morale due to the original accident.
XI. Overhead cost per injured worker—the expense of light, heat, rent and other such items, which continue while the injured employee is a nonproducer.

As Heinrich indicates, "This list does not include all the points that might well receive consideration, although it does clearly outline the vicious and seemingly endless cycle of events that follow in the train of accidents."

The items listed by Heinrich and the 4-to-1 ratio of indirect to direct accident costs are the product of detailed on-the-job cost analyses by experienced cost accountants. As a matter of fact, an exceedingly good case could be made for a considerably higher ratio, at least 5 to 1, and perhaps 6 to 1, for many analyses yield such or even higher figures. Probably the explanation for such variations lies in the fact that in some industries there is much more likelihood of damage to expensive equipment or material than there is in others. For example, in a steam power house, a paper mill, or a steel works, accidents involving enormously expensive damage to equipment are an ever-present possibility. In a plant working with expensive materials whose quality depends upon

accurate control, accidents are always likely to yield heavy losses from spoilage. On the other hand, there is much less likelihood of heavy incidental costs in plants not keyed to quantity production processes or plants that largely employ highly expensive equipment, as, for instance, the ordinary wood- or metal-working job shop, rock quarry, laundry, automobile repair shop, or the like.

Examples of cost analyses. The following accident cost analyses are reasonably representative samples of the findings of plant cost accountants. In each case, the responsible executive had assigned to the "cost man" the duty of appraising promptly the cost of each injury occurrence and reporting on the total at the end of the specified period. Each cost man had the Heinrich cost breakdown or its approximate equivalent. Cost of first-aid treatment is included in medical expense.

Example 1. Foundry and Machine Shop. One-year period. Lost-time injuries 11, first-aid cases 203. The accident occurrences were typical, the most serious being the spillage of a ladleful of molten iron due to cable breakage. This accident, in which two men were burned, involved most of the compensation paid:

Compensation paid	$203.00	
Medical expense	134.00	
Total direct cost	$337.00	
Lost-time detail:		
Injured employees (lost-time cases)		$ 34.68
Injured employees (first-aid cases)		156.80
Fellow workmen		102.00
Supervisory (judgment estimate)		80.00
Labor charge (clean-up of ladle spill on overtime)		64.00
Production loss:		
Down time		92.50
Lessened production rate		65.00
Material spoilage		36.00
Machine and equipment damage		343.00
Overhead and administrative (records, executive time, other administrative) estimated at		350.00
Total indirect cost		$1,323.98
Ratio—3.9 to 1.		

Example 2. Woodworking Shop. One-year period. Lost-time injuries 7, first-aid cases 210. The outstanding accident occurrence was a fire resulting from the spillage of a can of lacquer thinner. Three workers were burned, two being lost-time cases but neither serious. Most of the compensation paid was for a back strain suffered by the mechanic foreman who overlifted when moving a table saw. As a result of his injury, machine maintenance was neglected with serious loss of production.

Compensation paid	$ 98.00
Medical expense	145.00
Total direct cost	$243.00

Time Losses:		
Lost-time cases	$	23.00
First-aid cases		94.50
Other (estimated)		50.00
Fire damage		948.00
Material spoilage		11.00
Production loss		325.00
Total indirect cost		$1,451.50
Ratio—6 to 1.		

Example 3. Building Construction Job. Approximately 700,000 man hours. Lost-time injuries 31, 19 additional cases sent to doctor, first-aid treatments at job not reported on but estimate of cost included in appraisal. The only serious mishap was the breakage of a guy cable causing the collapse of a derrick, which fell across a truck and a shed filled with wall board. Truck driver's legs fractured and back injured.

Compensation paid	$323.00		
Medical expense	330.00		
Total direct cost	$653.00		
Unearned wages (time loss):			
Injured workmen		$	124.00
All others			314.00
To derrick collapse:			
Derrick repairs			714.00
Truck repairs			627.00
Material spoilage			607.00
Labor clean-up and rebuilding shed			345.00
Of the remaining accident occurrences, 17 involved damage to equipment or material totaling			940.00
Total indirect expense			$3,671.00
Ratio—5.6 to 1.			

Example 4. Chemical Plant. Six-months period. Lost-time injuries 27, first-aid cases 398. There were two serious occurrences: a digester rupture released acid-laden liquid which spread over a considerable floor area, damaging equipment and piled material and yielding one serious injury; a gas-heated dryer oven exploded yielding only a first-aid case, however.

Compensation paid	$243.40	
Medical expense	477.00	
Total direct cost	$720.40	
Fire damage		$6,600.00
Rebuilding oven and control equipment		724.00
Explosion damage to building		542.00
Spoilage (fire and explosion)		588.00
Lost time		173.00
Equipment damage (other than above)		197.00
Spoilage (other than above)		268.00
		$9,052.00
Add for unitemized costs		239.00
Total indirect cost		$9,291.00
Ratio—12.9–1.		

If the still rupture were excluded, the ratio would have been approximately 4.3 to 1.

Had there been any fatal or serious permanent disability cases in the above examples, they would have distorted the ratios so much as to throw them entirely outside the range of average or fairly representative conditions. However, a large enough sample of accidents representative of ordinary industrial operations would inevitably include some fatal and permanent disabilities. If included in the proportions in which they occur in the national injury toll, they would have little effect on the above ratios. Using the United States Bureau of Labor Statistics figures already quoted for 1941, we get per 100,000 lost-time cases

Fatal	881 or .88%
Permanent impairments	4,615 or 4.6%
Temporary disabilities	94,500 or 94.5%

If, for instance, on this basis a reasonable allowance for fatalities and permanent disabilities were added to the direct cost in Example 1, it would change the ratio only from 3.9 to 1 to 3.8 to 1.

It would be entirely proper in each of the foregoing examples to add an amount to the indirect cost for the occasional accidents that involve heavy expense with little or no injury to workmen. However, available data give little indication as to what this amount should be. Instances of accident occurrences of this type are not at all infrequent, however, for example:

1. Workmen, releveling the rails on which an electric overhead crane ran, left a section of rail unsecure. When the crane wheels hit it, it yielded, wrecking the crane. The operator was providentially thrown clear and escaped with only bruises. Total cost, including rebuilding crane and department down time was over $100,000.

2. A special self-contained extra-high-pressure pumping unit already crated for shipment was dropped because of breakage of the crane hook. It crashed through into the basement, wrecking some machinery there. A mechanic dressing the mushroomed head of a chisel on a bench grinder was startled by the crash and swung his elbow against the grinder, thus causing a painful but not disabling burn. Total loss $10,250.

3. The shaft of a small high-speed vertical engine broke, releasing the fly wheel which bounded down the aisle and into the generating room where it crashed into the main switchboard, smashed it, and caused a short circuit that burned out the main generator. The remaining generators were unable to carry the whole plant, thus making a large cut in production necessary until vital repairs could be made and a feeder line run in from an outside source of power. Loss over $95,000.

It should be emphasized here that many of the details of indirect accident cost will not be brought out by the usual cost system. This is particularly true of time loss by fellow employees, executives, and supervisors, and may apply to material spoilage,

machine and equipment damage, and production loss as well. Therefore, in order to get reasonably accurate results, it is necessary that a competent cost man make a prompt detailed investigation of each accident and set down each item of cost. If this is consistently done for all accidents in a given establishment during a considerable period (say a year in a small plant), the true picture will come out. Otherwise, it will not.

Cost to injured workers

Injured workers themselves, however, are the heaviest losers. Their actual losses in money may not be so great as the employer's losses, but workers are less able to afford their share of the financial burden, and, in addition, it is they who must bear the physical pain and suffering that accompany every injury. If injured while on the job, the worker of course does not have to pay his own hospital and doctor bills, and he does receive some income in the form of workmen's compensation if he is under a compensation act or covered by insurance. But if injured while off the job, he not only loses his pay during the time he is unable to work, but, in addition, must pay his own bills for medical and hospital attention. Accordingly, his expenses pile up while his income and savings dwindle.

An idea of the magnitude of the loss of income that injured workers as a whole suffer in spite of compensation payments can be gained as follows: National Safety Council estimated the wage loss due to industrial injuries in 1940 at $490,000,000. Subtracting the total compensation paid that year of $257,000,000, we find that the injured workers' loss was $233,000,000. In other words, total compensation was only a little over half the total wage loss.

This loss does not fall upon the shoulders of the injured man alone. Unfortunately, his wife and children must bear their share of the burden when the breadwinner's pay check is decreased or cut off. All too frequently an accident to the father means that the mother or an older child must go to work to increase the family income, perhaps ruining plans to build a home or to educate the children. One accident can easily wreck not only the life of the person injured, but also the lives of all members of his family.

Cost to society

Industrial accidents also place a heavy burden upon society in general. Even though the employer pays compensation for on-the-job accidents, injured workers and their families frequently require financial help or support from such social agencies as hospital

associations, community chests, and other relief organizations. Much of this financial burden may be carried by organized philanthropies, but a good share of it must necessarily be borne by agencies that are supported entirely by taxes.

Accidents increase the cost of living

Employers, to remain solvent, naturally include their accident costs when figuring the selling prices of the products they manufacture or handle, so accidents increase the cost of everything that is sold. Looking at it from the other point of view, every one of the over 131,000,000 people in America helps to pay the costs of industrial accidents every time he buys anything from a paper of pins to an automobile.

REVIEW

1. What is the approximate average cost of each lost-time injury to the employer?
2. What is meant by direct accident cost? Indirect?
3. List the chief items of indirect cost.
4. Should one assume that in each accident the 4-to-1 ratio applies?
5. Why does the ordinary cost system not show indirect accident costs?
6. How are the indirect costs to be obtained?

CHAPTER IV

Appraising Safety Performance

Nearly every industrialist, when asked if his accident record is good or bad, answers "Good." Some few may be answering correctly, but the great majority are wrong; the truth is they just don't know. Even if they are informed concerning the exact number of accidents in their plants, they still do not know whether that number represents a good record or a bad one. In fact, no one can answer such a question intelligently unless he knows at least three things:

1. The accident frequency rate of his firm.
2. The accident severity rate of his firm.
3. How these rates compare with the rates representative of good practice in his or similar industries.

Accident frequency rate

The accident frequency rate answers the question, "How often do accidents occur?" and it is defined as the number of disabling[1] injuries per 1,000,000 man-hours worked. Expressed as a mathematical formula:

$$\text{Accident frequency rate} = \frac{\text{number of disabling injuries} \times 1{,}000{,}000}{\text{total number of man-hours worked}}.$$

Accident severity rate

The accident severity rate answers the question, "How serious are the accidents?" and is defined as the number of days of lost time per 1,000 man-hours worked.[2]

$$\text{Accident severity rate} = \frac{\text{number of days lost} \times 1{,}000}{\text{total number of man-hours worked}}.$$

[1] A disabling injury as usually defined in practice is one causing loss of working time beyond the day shift or turn during which the injury was received. For exact definition see the "American Standard" Method of Compiling Industrial Injury Rates, published by the American Standards Association, 29 W. 39th Street, New York City.

[2] An arbitrary time charge is made for death or permanent disability. See page 32 for these charges.

Use of accident rates

The chief values of accident rates are:

1. To measure the accident experience of a given department, branch, or firm.
2. To determine from month to month or year to year whether that experience is getting better or worse.
3. To prepare the experience of one operating unit with one or more other units.
4. To serve as a basis for an accident-prevention contest between two or more operating units.

In general, accident rates answer the question, "Is additional accident prevention effort needed?" Such rates naturally do not indicate definitely what needs to be done; this question requires further study and calls for other procedures.

Examples. Obviously, accident rates can be calculated for a week, a month, or a year, or for any period of time by using the same formulas. Furthermore, the same formulas are used to compare the records of two or more plants even though they are dissimilar in size.

Example 1. What are the accident frequency and severity rates for a firm with 80 workers averaging 40 hours a week each, if in 6 months 4 workers were injured and if they lost jointly 103 days from work?

$$\text{Accident frequency rate} = \frac{\text{4 injuries} \times \text{1,000,000 man-hours}}{\text{80 workers} \times \text{40 hrs. a week} \times \text{26 weeks}} = 48.+.$$

$$\text{Accident severity rate} = \frac{\text{103 days lost} \times \text{1,000 man-hours}}{\text{80 workers} \times \text{40 hrs. a week} \times \text{26 weeks}} = 1.2.$$

Suppose for one of the above 4 injuries involving, say, 13 days lost time, we substitute an injury in which thumb and forefinger were amputated. The time charge would be 1,200 days. The example then becomes

$$\frac{\text{1,290 days lost} \times \text{1,000 man-hours}}{\text{80 workers} \times \text{40 hrs. per week} \times \text{26 weeks}} - 15.5.$$

Note that, when an injury involves a time charge, the actual time the injured person is off is ignored.

Example 2. Firm A has 115 workers averaging 40 hours a week each; in 9 months, 3 workers were injured. Firm B has 132 workers averaging 37 hours a week each; in 10 months, 3 workers were injured. Which firm has the better accident frequency rate?

$$\text{A frequency rate} = \frac{\text{3 injuries} \times \text{1,000,000}}{\text{115 workers} \times \text{40 hrs. per week} \times \text{39 weeks}} = 16.2.$$

$$\text{B frequency rate} = \frac{\text{3 injuries} \times \text{1,000,000}}{\text{132 workers} \times \text{37 hrs. per week} \times \text{43.3 weeks}} = 14.2.$$

Firm B has the better accident frequency rate.

Definitions and rulings

For the sake of uniformity, all injury-rate data should be compiled and the rates computed in accordance with the provisions of the "American Standard" Method of Compiling Industrial Injury Rates.

Why use different man-hour bases?

The questions are sometimes asked, "Why do we use *per 1,000,000 manhours worked* in calculating frequency rates, and *per 1,000 manhours worked* in calculating severity rates?" "Why don't we use the same basis in both formulas?" The reason is that, by using two different bases, both rates are likely to be numerals between 1 and 99. If the same basis were used in both formulas, one rate would probably be unnecessarily high (3 or 4 digits), and the other rate would be unnecessarily low (less than 1). Two-digit numbers are much more easily remembered than are decimals or 3- or 4-digit numbers.

Scale of time charges

The American Standard Scale is:

Death	6,000
Permanent total disability	6,000
Arm, at or above elbow	4,500
Arm below elbow	3,600
Hand	3,000
Thumb	600
Any one finger	300
Two fingers, same hand	750
Three fingers, same hand	1,200
Four fingers, same hand	1,800
Thumb and one finger, same hand	1,200
Thumb and two fingers, same hand	1,500
Thumb and three fingers, same hand	2,000
Thumb and four fingers, same hand	2,400
Leg, at or above knee	4,500
Leg, below knee	3,000
Foot	2,400
Great toe or any two or more toes, same foot	300
Two great toes	600
One eye, loss of sight	1,800
Both eyes, loss of sight	6,000
One ear, loss of hearing	600
Both ears, loss of hearing	3,000

The loss of 6,000 days assigned to "death" in the above scale is not an arbitrary figure as might be assumed, nor is it related to the Workmen's Compensation payments which, incidentally, differ widely among the various states. Instead, the scale, when it

was devised, was based on statistics furnished by the life insurance companies which showed that, during the period covered by the data in question, the average man killed in an industrial accident had a working life expectancy of approximately 20 years or 6,000 days. Permanent total disability is given the same lost-time weighting as is death, and other permanent disabilities are charged with fractions of the 6,000-day total.

Why not include first-aid cases when calculating accident rates?

By definition, first-aid cases are accidents just as are fatality or permanent injury cases, and some persons argue that these should be included in the calculation of accident-frequency and severity rates. Some safety engineers have followed this suggestion and have been surprised to see an increase in the number of infections. This is the usual result of including minor injuries in the basis of comparison. Such inclusion creates an incentive to let minor injuries go unreported, hence, untreated, and the consequence is infections. Under pressure to reduce accidents, some supervisors will restrain injured employees from reporting for first aid. In the heat of a contest, the workers themselves are likely to hide nondisabling injuries even from their foreman. First-aid treatment of all injuries is vitally important, and any procedure that works against it should be avoided.

Which rate to use

There is a great difference of opinion among safety engineers as to which rate is the better measuring stick, and good arguments are advanced on both sides of the question. It seems obvious that a large reduction in the accident-severity rate indicates a sizeable reduction in deaths and other serious injuries; and after all, this is more important from both the humanitarian and financial points of view than is a reduction of the less serious accidents that necessitate the loss of only a few days' time each. Conversely, if the severity rate were to increase even though the frequency rates were to go down, it might indicate a definite need for more intensive engineering work to eliminate some especially hazardous conditions that otherwise might not be given sufficiently serious consideration.

Every accident a potential death case

Several factors, however, must be considered on the other side of the argument. Every accident is a potential death case even though it may result in a very minor injury or in no injury at all. Therefore the efforts of the safety engineer must be aimed at the

elimination of *all* accidents, not at the elimination of just the more serious ones.

Luck—a big factor in severity

Severity is much more a matter of good luck or bad luck than is frequency. For example: In plant A a hammer may fall from an elevated platform, hit a worker directly on the head, cause his death, and call for a charge of 6,000 lost days. Another accident of the same type may occur in plant B, but this time the hammer falls directly to the ground, luckily hitting no one, and not calling for any time charge whatever. From an accident-prevention point of view, both accidents are of equal importance, but the factor of chance brought plant A a severity charge of 6,000, which plant B escaped. This accident added only one injury to plant A's frequency base, however, and of course nothing to plant B's. Obviously, then, when comparing the records of the two plants, the frequency rate eliminates the luck factor much more than does the severity rate. This is the basis for the slogan, "Take care of the frequency rate and the severity rate will take care of itself."

Frequency best for contest purposes

If two or more operating units are competing, as in an accident-prevention contest, it therefore is wise to use the accident-frequency rate as the basis for comparison. If the severity rate is used, and if one competitor is unfortunate enough to have a death, the workers in that group immediately lose interest because they know they are out of the running.

Adjusted frequency rate for contest purposes

Straight frequency rates do not provide a perfect basis for comparing the accident experience of competitors in an accident-prevention contest if there is a considerable difference in the hazards with which the workers are confronted. For example, it does not seem fair to compare a foundry directly with a cigar factory. Under such circumstances, it may be advisable to provide adjusting factors that make suitable allowance for the difference in hazards. The adjusting factors used most frequently are the manual rates quoted by insurance companies for carrying the workmen's compensation insurance of the various competitors. Another set of adjusting factors might well be the average frequency rate for each industry represented by the competing units.

Other bases for accident-prevention contests

In some contests, that competitor is declared to be the winner who achieves the greatest percentage reduction in his frequency rate as compared with his own former average. This plan, however, is likely to give too great an advantage to those competitors who had the worst former averages, because it is usually much harder to reduce a frequency rate of, say 6, one third than it is to secure a similar reduction in a rate five times that figure.

After a number of competing units have proved their ability to go for long periods of time without any disabling injuries—that is, when many of the competitors are tied for first place with perfect accident records—it may be advisable to change the plan of contest so that the winner will be that unit which succeeds in operating the greatest number of man-hours without any disabling injuries.

Other means of quick appraisal

It sometimes is said, "Show me an establishment in which there is good housekeeping, and I'll know that that outfit has a good accident record." This, of course, is not an infallible method of appraising the accident experience of any firm, but there is no doubt that it is difficult if not impossible to have a good accident record without simultaneously maintaining good housekeeping conditions.

In a similar way, other quick means of appraisal are provided by rating such factors as plant maintenance, machine guarding, lighting, ventilation, operating methods, supervision, and the attitude of the top executives. These and other factors are so closely related to good safety performance that jointly they provide a thoroughly reliable gauge of results to experts who have considerable knowledge in the whole field of safety. Even such experts, however, have learned that they cannot place complete reliance upon an analysis of these factors unless their judgment is backed up also by a knowledge of the accident-frequency and severity rates.

How to present accident rates

The safety engineer should make sure that all executives and supervisors in his firm understand the method of calculating accident-frequency and severity rates so that they will be able to interpret the reports that he submits for their consideration. On the other hand, however, he will often want to supplement his statistical data with bar charts, curves, and other visual interpreta-

tions of the accident record so that his associates can grasp the outstanding facts at a glance.

Credibility of accident rates

The exposure (total number of man-hours worked) on which to calculate accident rates should be as large as possible. More credibility is attached to rates covering large exposures than to those covering small exposures. Some authorities consider 1,000,000 man-hours the minimum exposure whose frequency rate may be accepted as a reliable gauge of safety performance during the period in question. Others believe that considerably smaller exposures are satisfactory for the purpose. It is obvious that the fewer the man-hours the greater the need of careful appraisal of such indicative plant and operating conditions as housekeeping, maintenance, machinery safeguarding, attitude of management, and so on.

Since chance plays so large a part in determining severity and, further, since the time charges are individually so large, it is evident that the number of injuries involved—that is, the size of the sample—is more important than the man-hour exposure. The sample used on page 31 to illustrate the calculation of severity brings this point out clearly. One authority gives the figure of 1,000 lost-time injuries as about the minimum that can be accepted as an entirely reliable base for severity. Others would accept 100 injuries as reasonably satisfactory. However, in so small a sample as 100 injuries, the addition or subtraction of a single fatality will usually multiply or divide the severity rate several times.

The following conclusions appear to be justified:

1. Use frequency rates based on large exposures (over 1,000,000 man-hours) as quite reliable gauges of safety performance.
2. Use severity rate as a satisfactory gauge of the seriousness of injuries characteristic of specific industries or occupations provided the base is large, preferably on the order of 1,000 injuries or more.
3. The smaller the exposure on which the frequency rate is based and the smaller the sample for which the severity rate is calculated, the greater the need for supplemental evidence obtained by analysis of the accident record, operating conditions, and the types of hazards involved.

Rates to use for comparison

An executive, when considering his own injury rates, wants to make two comparisons: how his rates compare to those of others

in the same industry, and how his rates compare with those representative of best practice. The second comparison is obviously the vital one to every executive who wishes to be better than "just average."

The Bureau of Labor Statistics of the United States Department of Labor compiles frequency and severity rates by industries annually on a national basis.[3] These rates are believed to be the most reliable available because the Bureau's very large coverage is supplemented by careful sampling designed to secure true averages. However, the frequency rates usually used for comparison purposes are those computed annually by the National Safety Council. The accompanying table shows the rates compiled for the year 1941.

Industry	*Disabling Injuries per 1,000,000 Man-hours*	*Days Lost per 1,000 Man-hours*
Tobacco	3.23	.20
Cement	5.99	2.22
Steel	7.02	1.75
Glass	7.37	.50
Aeronautics	7.40	.30
Automobile	7.49	.64
Rubber	8.10	.62
Chemical	9.48	1.30
Laundry	9.79	1.15
Printing & Publishing	9.87	.35
Textile	10.23	.53
Machinery	10.66	.79
Petroleum	11.78	1.44
Public Utility	12.70	1.66
Non-Ferrous Metals	13.17	1.63
Sheet Metal	14.37	.83
Transit	14.99	1.16
All Industries	15.39	1.53
Meat Packing	15.70	1.42
Tanning & Leather	15.88	.82
Food	16.16	1.30
Metal Products	16.61	1.30
Paper & Pulp	17.37	1.66
Quarry	17.96	3.71
Foundry	21.27	1.33
Woodworking	22.44	1.04
Marine	22.82	1.61
Construction	27.11	2.42
Clay Products	30.82	1.33
Refrigeration	37.59	1.92
Mining	38.90	9.42
Lumbering	52.45	5.19

It should be kept in mind that these Council rates are not averages for *all* the firms in any classification; that is, they are *not*

[3] Published annually in *Monthly Labor Review*, U. S. Department of Labor.

national averages. They cover a very large number of establishments, but even this large number constitutes but a small percentage of American industry. Furthermore, the percentage of each industry covered varies widely as among the various industries. It should be obvious that Council membership or even voluntary reporting of injury data to the Council is evidence of greater than average interest in safety and, therefore, that these figures represent better than average performance. This conclusion is borne out by the fact that the average frequency rates given by the Council run generally lower than those given by the Bureau of Labor Statistics. For example, for 1941 the Council frequency rate for steel was 7.02 while the Bureau of Labor Statistics figure was 10.2; for rubber, the rates were 8.10 and 16.2 respectively; and for construction, 27.11 and 47.5 respectively. Such comparisons are not exact, however, because these two agencies do not use identical classifications, but the evidence does in general justify the above conclusion.

Statistically adequate data as to just what frequency rates represent top safety performance in each of the various industries are not available, and we must, therefore, base our judgment on the accomplishment of individual firms. Fortunately such data, while scattered, nevertheless cover numerous establishments throughout American industry. Specifically reported accompiishments abundantly justify the conclusion that even for such high-hazard industries as steelmaking, heavy construction, and mining, best existing practice yields frequency rates well below 10 while for the bulk of industry top performance is below 5.

Three outstanding facts seem to be proved by the National Safety Council and Bureau of Labor Statistics data:

1. Those industries in which large firms predominate have achieved relatively low frequencies; for example, the steel and automobile industries.

2. Those industries in which small firms predominate still have relatively high frequencies; for example, the food industry.

3. Even some of the so-called hazardous industries that have been doing safety work for a number of years on an industry-wide basis have achieved remarkably low frequencies; examples, steel versus construction; cement versus sawmills.

No-injury records in American industry

The accompanying table, based on 1942 *Accident Facts,* gives a partial list of the best all-time no-injury records of individual establishments known to the National Safety Council.

The list includes only the best record for each of a few major industrial classifications. Each record shows the number of continuous man-hours worked without a disabling injury.

ALL-TIME NO-INJURY RECORDS OF INDIVIDUAL ESTABLISHMENTS

Industry	*Company and Plant or Location*	*Injury-free Man-hours*
Tobacco	BAYUK CIGARS, INC., Philadelphia, Pa.	14,314,436
Chemical	E. I. DU PONT DE NEMOURS & CO., Old Hickory, Tenn.	11,361,846
Machinery	GENERAL TIME INSTRUMENTS CORP., Westclox Div., La Salle, Ill.	11,114,600
Textile	THE TRION CO., Trion, Ga.	10,495,544
Glass	RAYTHEON PRODUCTION CO., Newton, Mass.	7,243,532
Petroleum	STANDARD OIL CO. (Indiana), Wood River Refinery	6,879,296
Metal products (misc.)	U. S. STEEL CORP., American Steel and Wire Co., Joliet, Ill.	6,442,278
Automobile	GENERAL MOTORS CORP., Janesville, Wis.	5,835,076
Sheet metal	C. HAGER & SONS HINGE MFG. CO., St. Louis, Mo.	5,808,921
Rubber	U. S. RUBBER COMPANY, Providence, R. I.	5,688,369
Steel	REPUBLIC STEEL CORP., Corrigan McKinney Steel Co., Cleveland, Ohio	5,325,144
Non-ferrous metals	ALUMINUM COMPANY OF AMERICA, Alcoa, Tenn.	4,955,909
Public utilities	FALL RIVER ELECTRIC LIGHT CO., Fall River, Mass.	4,337,640
Laundry	BRUNSWICK LAUNDRY CO., Jersey City, N. J.	4,174,257
Tanning, leather	BROWN SHOE CO., Brookfield, Mo.	4,149,174
Meat packing	ARMOUR & CO., Sioux City, Iowa	4,054,449
Food	PETER CAILLER KOHLER SWISS CHOCOLATE CO., Fulton, N. Y.	3,904,841
Cement	LEHIGH PORTLAND CEMENT CO., Iola, Kans.	3,579,883
Paper and pulp	HOLLINGSWORTH & WHITNEY CO., Waterville, Me.	3,343,623
Construction	E. I. DU PONT DE NEMOURS & CO., Memphis, Tenn.	3,079,500
Printing, publishing	CANADIAN BANK NOTE CO., Ottawa, Can.	2,716,151
Woodworking	TOMLINSON OF HIGH POINT, INC., High Point, N. C.	2,298,758
Clay products	A. P. GREEN FIRE BRICK CO., Mexico, Mo.	2,064,942
Foundry	ALUMINUM COMPANY OF AMERICA, Los Angeles, Calif.	2,034,419
Quarry	MICHIGAN LIMESTONE AND CHEMICAL CO., Rogers City, Mich.	1,809,965
Marine	ERIE RAILROAD CO., Marine Dept., Jersey City, N. J.	1,525,140
Mining	WAKEFIELD IRON CO., Gogebic, Mich.	1,243,854
Transit	CAROLINA POWER & LIGHT CO., Bus Transportation Dept.	1,169,604
Lumbering	POTLATCH FORRESTS, INC., Lewiston, Idaho	564,130

One of the outstanding facts learned from these and other available records is that *some* establishments in each of even the

most hazardous industries, as for instance construction, lumbering, and coal mining, have achieved very low frequency rates.

Careful analyses of the methods used by such firms appear to justify the conclusion that the only reason why any firm in any industry has a high rate of injuries is simply that its top executives have not become sufficiently interested in safety to require better performance from their operating personnel in this respect. Any management can have an excellent accident record if it will make safety an important part of its managerial duties.

REVIEW

1. Define frequency rate.

2. Define severity rate.

3. What is the value of injury rates?

4. Is a frequency rate based on one million man-hours a fairly reliable index? A severity rate?

5. Why not include first-aid cases in figuring frequency rates?

6. What other means are there of appraising safety performance?

7. What frequency rates are representative of top safety performance?

8. Why are National Safety Council frequency rates better than national averages?

CHAPTER V

Circumstances Surrounding Accidents

Mass statistics

Many organizations and individuals collect and tabulate reports concerning the circumstances surrounding industrial accidents. Leaders in this field are National Safety Council, United States Census Bureau, United States Bureau of Labor Statistics, insurance companies, state departments, trade associations, and others. Naturally, great numbers of these reports find their way into the hands of safety engineers all over the country, and unfortunately, after giving them a quick "once-over," many engineers turn away confused and extremely critical of the statisticians who "spoil so much good white paper with their meaningless figures."

The following are some of the reasons why many safety engineers become confused:

1. They soon learn that "accidents are caused, they don't simply happen"; and, "the way to prevent accidents is to discover and eliminate causes." Thus, when they start to look for an acceptable list of causes, they are confronted with so many possible choices that they do not know which way to turn.
2. Many statistics imply incorrectly that every accident is the result of just one cause. The fact is that almost every accident results from a combination of causes.
3. Many unimportant statistics are made to appear important, and the safety engineer is given very little assistance in differentiating one from the other.
4. Some statistics overemphasize the question "Who was to blame?"
5. The words "accident" and "injury" are used so indiscriminately that they frequently cause misunderstanding.
6. So many undefined terms are used, such as "agency," "type of accident," "nature of injury," "unsafe acts," "unsafe conditions," "causes," "proximate causes," and "sub-causes."
7. Statistics vary so widely that they are not comparable.
8. Many statistics on such subjects as hour of the day, day of the week, week of the month, month of the year seem completely without value.

Unfortunately, much of this criticism of mass statistics is amply justified, but there are several arguments on the other side of the question that need to be considered:

1. Many of these statistics have nothing whatever to do with accident prevention; instead, they may be prepared for legislative, insurance, sociological, or census purposes.
2. Mass statistics do provide records from the past that may be especially valuable to firms just starting safety work.
3. They do justify certain conclusions that might not be justified from smaller exposures.
4. They indicate that the circumstances surrounding the great majority of all industrial accidents are similar for all establishments regardless of size, branch of industry, or geographical location.

Tables 1 to 8, on pages 47 to 53, illustrate a few selected statistical tabulations that are particularly interesting and valuable.

Terms used in describing accidents

At this point, it might be well to define and discuss some of the terms used in describing the circumstances surrounding accidents.

An accident may be defined as "any occurrence that interrupts or interferes with the orderly progress of the activity in question." Some accidents involve human injury, but most of them do not. For instance, a hoisting chain may break, dropping a load of steel bars to the floor. This is an accident but not an injury. It is generally agreed that the safety engineer's first responsibility is to prevent injuries, but it is obvious that if he can make a job or an activity go exactly as planned he will thus eliminate all accidents and with them all injuries. Accordingly, most safety engineers look at their responsibilities from this broader point of view and endeavor to prevent accidents of all types whether they cause injuries or not.

The National Safety Council describes an accident as "an event or rapidly occurring series of events, arising out of an unsafe act or an unsafe condition, and culminating in an unpremeditated injury. In any such series of events it will be found that: (a) some agency such as a machine, tool, object, or material was involved; (b) the injured was performing some task or job at the time; and (c) contact was made in some manner between his body and the agency."

Heinrich has compared the series of events in an accident to a series of dominoes standing on end so arranged that when the

first is pushed over it will cause the others to fall successively. Injury is the final domino. Preceding the injury is the accident or occurrence, such as the fall of a person or of an object. Preceding the accident that produces the injury there is the cause that may be an unsafe act of the man injured or an unsafe condition, or both. Preceding these are subcauses (reasons for the causes).

The agency is the object, substance, or exposure which is most closely associated with the injury and which could have been made safer. (See Tables 1 and 3.) The common agencies of industrial accidents are such things as:

1. Machine, pump, prime mover.
2. Elevators and hoisting apparatus.
3. Conveyors.
4. Boilers, pipe and pressure apparatus.
5. Vehicles.
6. Mechanical power transmission apparatus.
7. Electrical apparatus.
8. Hand tools.
9. Chemicals.
10. Other materials.
11. Other working surfaces.

This list of course can be varied to suit the needs of the individual firm. When selecting the agency of an accident it is best to select that unsafe object, substance, or exposure that could most easily be made safe. For example, an oiler is injured while climbing a ladder; the ladder slipped. The ladder is the agency; it could have been equipped with nonslip ladder shoes, or it could have been tied to prevent slipping, or it could have been held in position by a helper.

The accident type is the manner of contact of the injured person with an object, substance, or exposure, or the movement of the injured person which resulted in the injury. (See Tables 2, 6, and 7.) The major types of accidents are:

1. Fall of person—same level.
2. Fall of person—one level to another.
3. Slips (causing strains; not falls).
4. Falling, sliding, flying objects.
5. Caught in or between.
6. Struck against.
7. Drowning or immersion.
8. Burning or scalding.
9. Electric shock.

10. Inhalation, absorption, swallowing.
11. Poisoning.
12. Other types.

The unsafe act is that violation of a commonly accepted safe procedure which resulted in the selected accident type. (See Tables 3 and 4.) Unsafe acts may be classified in the following general groups:

1. Operating without authority, failure to secure or warn.
2. Operating or working at unsafe speed.
3. Making safety devices inoperative.
4. Using unsafe equipment, hands instead of equipment, or equipment unsafely.
5. Unsafe loading, placing, mixing, combining, and so on.
6. Taking unsafe position or posture.
7. Working on moving or dangerous equipment.
8. Distracting, teasing, abusing, startling, and so on.
9. Failure to use safe attire or personal protective devices.

The unsafe personal cause (sometimes called the "behavioristic cause") is the mental or bodily characteristic which permitted or occasioned the selected unsafe act. (See Table 4.) Personal causes are usually classified as:

1. Improper attitude (deliberate chance-taking, disregard of instructions, injured man knew how to do his job safely, but he failed to follow safe procedure, absentminded, etc.).
2. Lack of knowledge or skill (injured man did not know how to do his job safely, too new on the job, unpracticed, unskilled, etc.).
3. Physical or mental defect (one arm, deaf, epilepsy, partially blind, etc.).

The unsafe mechanical or physical cause (sometimes called the "environmental cause") is the condition of the selected agency which could and should have been guarded or corrected. (See Tables 3 and 4.) These causes are frequently classified as:

1. Improper guarding (unguarded, inadequately guarded, guard removed, etc.).
2. Defective agencies (broken, poorly designed, slippery, defective brakes, rough, sharp, slippery, decayed, corroded, frayed, cracked, etc.).
3. Hazardous arrangement, process, etc. (piling, storage, aisle space, exits, layout, planning, overloading, misaligning).
4. Improper illumination (poor, none, glaring headlights, etc.).

5. Improper ventilation (poor, dusty, gaseous, high humidity, etc.).

6. Improper dress or apparel (goggles, gloves, shoes, masks, sleeves, etc.).

The following is a slightly different list of environmental causes which some safety engineers prefer to the one presented in the preceding paragraph.

1. Improper guarding (unguarded, inadequately guarded, guard removed by someone other than injured worker, etc.).
2. Substances or equipment defective through use or abuse (worn out, cracked, broken, etc. through no fault of injured worker).
3. Substances or equipment defective through design or construction (too large, too small, not strong enough, made with flaws, etc.).
4. Unsafe procedure (hazardous process, management failed to make adequate plans for safety).
5. Unsafe housekeeping facilities (unsuitable shelves, bins, racks; no aisle markings, etc.).
6. Improper illumination (poor, none, glaring headlights, etc.).
7. Improper ventilation (poor, dusty, gaseous, high humidity, etc.).
8. Improper dress or apparel (management's failure to provide or specify use).

This list of environmental causes (discussed in further detail in Chapter VI) is especially valuable when the safety engineer is confronted with the problem of deciding (a) what action is necessary to prevent the recurrence of similar accidents, and (b) who is responsible for carrying out the agreed-upon action.

Perhaps more uncertainty will arise in connection with the last of these 8 causes, "unsafe dress or apparel," than with any of the others. But here are several suggestions that will help to eliminate this uncertainty. (a) If the management can reasonably be expected to provide (or specify the use of) certain safe dress or apparel for a given job but fails to do so, then any injury resulting from such failure should be charged to this cause. (b) On the other hand, if the management does provide safe dress or apparel for a certain job, and if the management makes a reasonable effort to enforce its use, but the worker fails to use it, then any injury resulting from such worker failure should not be charged to this cause. (c) In a similar way, if the management specifies the use of certain safe dress or apparel that the worker can reasonably

be expected to provide, then any injury resulting from a worker failing to comply with this specification should not be charged to this cause.

Examples. Charge to "unsafe dress or apparel" certain accidents if management does not provide goggles for chippers, or if management does not provide protective faceshields for electric welders, or if management does not specify the use of safety shoes in a heavy machine shop, or if management does not provide safety belt for window washer. Do not charge to "unsafe dress or apparel" certain accidents if a worker fails to use goggles (or respirator, and so on) that are provided by management and if the management made a reasonable effort to enforce their use.

Environmental vs. behavioristic causes

Most safety engineers when analyzing the circumstances surrounding accidents use to good advantage such lists as those presented on pages 43 to 45. There has been some variation, however, in the conclusions at which they have arrived. For instance, Heinrich concluded from a study he made that 88 per cent of all industrial accidents are caused primarily by the unsafe acts of persons, and the remaining 12 per cent are due chiefly to defective or dangerous physical or mechanical conditions.

A similar study conducted by the National Safety Council (see Table 4) shows that:

1. 18 per cent are due wholly to mechanical causes.
2. 19 per cent are due wholly to personal causes.
3. 63 per cent are due wholly to a combination of both causes.
4. 81 per cent are due wholly or in part to mechanical causes.
5. 82 per cent are due wholly or in part to personal causes.

A third analysis made by the state of Pennsylvania (see Table 3) indicates:

1. 3 per cent are due wholly to mechanical causes.
2. 2 per cent are due wholly to unsafe acts.
3. 95 per cent are due wholly to a combination of both.

It should be pointed out that differences in personal judgment may account for part of the variation in the above results. In the Heinrich study, only one cause of major importance was assigned to each accident, while in the last two studies the methods that were used permitted both kinds of causes to be assigned to each accident.

Carelessness not a cause of accidents

It should be noticeable by now that at no time thus far has there been any mention of "carelessness" as a cause of accidents. And yet, how often we hear people make such statements as, "Eighty per cent of all accidents are due to carelessness." It is unfortunate that so many persons think this statement is true. *Carelessness is not a cause of accidents.* Instead it is an alibi for industrial executives, foremen, and others who unthinkingly are placing the blame for accidents on the workers who are injured. It serves as a boomerang, too, for its use condemns the person who uses it; it is an unthinking admission on his part that he is making little or no intelligent effort to control the actions of the workers.

TABLE 1

AGENCIES OF OCCUPATIONAL INJURIES

Agency	Total	Manufacturing	Non-Manufacturing
Total	100.00%	100.00%	100.00%
Vehicles	13.23	10.19	15.02
Trucks	2.95	2.02	3.51
Passenger automobiles	2.12	2.60	1.83
Hand and foot operated	1.51	2.49	.93
Railway cars	1.23	.69	1.54
Other	5.42	2.39	7.21
Machinery	10.37	20.48	4.39
Grinding wheels	.68	1.64	.11
Lathes	.40	1.02	.02
Power presses	.35	.93	.01
Road	.22	.01	.35
Circular power saws	.18	.46	.02
Other	8.54	16.42	3.88
Hand tools	9.43	9.80	9.21
Knife	1.06	.92	1.15
Shovel and spade	.60	.33	.75
Wrench	.54	.75	.42
Hammer	.53	.71	.42
Other	6.70	7.09	6.47

Agency	Total	Manufacturing	Non-Manufacturing
Working surfs.	5.95	4.87	6.58
Floors	1.90	2.14	1.75
Others	4.05	2.73	4.83
Chemicals	4.30	5.27	3.73
Hot & corrosive substances	3.02	4.24	2.30
Other	1.28	1.03	1.43
Hoist. apparatus	1.16	1.68	.86
Overh'd cranes	.35	.90	.03
Shovels, derricks, dredges	.20	.04	.30
Other	.61	.74	.53
Conveyors	.93	.59	1.13
Elect. apparatus	.42	.35	.47
Prime movers and pumps	.39	.20	.50
Elevators	.32	.34	.31
Other agencies	53.50	46.23	57.80
Brick, rock, etc.	5.58	1.36	8.08
Boxes, benches, chairs, etc.	2.97	2.97	2.96
Stairways	1.70	1.28	1.96
Sheet & plates	1.64	2.09	1.37
Other	41.61	38.53	43.43

Source: Pennsylvania Department of Labor and Industry. Classification of cases was made in accordance with the American Standards Association code for compiling industrial accident causes.

TABLE 2

TYPE OF ACCIDENT AND PART OF BODY INJURED, COMPENSATED OCCUPATIONAL INJURIES

Type of Accident	Total	Eye	Arm	Hand	Thumb and Finger	Leg	Foot	Toe	Other Parts and General
ALL CASES (INCLUDING DEATHS AND PERMANENT TOTAL DISABILITIES)									
No. of cases	232,068	8,982	20,959	19,051	50,956	30,723	17,474	11,049	72,874
Average compensation	$274	$328	$319	$165	$170	$297	$163	$116	$397
PERMANENT PARTIAL DISABILITIES									
No. of cases	49,866	1,693	4,437	2,972	19,702	4,398	2,332	3,222	11,110
Average compensation	$699	$1,596	$1,135	$746	$366	$1,236	$707	$257	$878
All Types	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Handling objects	21	7	13	20	26	10	22	56	11
Falls	16	1	50	14	5	47	35	3	16
Machinery	25	13	11	25	39	5	8	7	12
Vehicles	8	2	13	8	7	17	11	5	13
Using hand tools	8	28	2	8	10	2	3	5	11
Falling objects	8	14	3	4	4	10	13	20	18
All other types	14	35	8	21	9	9	8	4	19
TEMPORARY DISABILITIES									
No. of cases	179,462	7,278	16,480	15,873	31,401	26,206	15,123	7,823	59,278
Average compensation	$92	$28	$88	$54	$41	$120	$74	$56	$134
All Types	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Handling objects	25	3	20	20	27	12	20	33	38
Falls	19	1	26	8	2	36	13	3	22
Machinery	9	5	6	10	21	3	3	4	3
Vehicles	8	1	11	6	8	12	10	8	12
Using hand tools	8	10	8	16	19	6	8	7	4
Falling objects	11	53	7	7	9	14	23	39	10
All other types	20	27	22	33	14	17	23	6	11

Courtesy National Safety Council.

Source: Reports of Seven State Labor Departments or Industrial Commissions: Illinois, Maryland, New Jersey, New York, Pennsylvania, West Virginia and Wisconsin—Some details partially estimated.

Table 3

UNSAFE ACTS AND MECHANICAL CAUSES OF OCCUPATIONAL INJURIES, BY AGENCY

Unsafe Act or Cause	All Injuries*	Machines	Elevators	Hoists and Conveyors	Electrical Apparatus	Motor Vehicles	Other Vehicles	Hand Tools	Chemicals	Working Surfaces	Ladders
UNSAFE ACT											
Total Cases	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Overloading, poor arranging	46	19	32	31	36	30	41	19	36	79	80
Unnecessary exp. to danger	18	9	28	29	10	36	35	16	10	1	4
Unsafe, or improper use eqp.	18	54	31	28	31	28	12	55	6	5	11
Non-use pers. protect. equip.	11	11	1	4	5	1	3	9	33	1	**
Work. on mov. or dang. eqp.	2	5	2	4	16	1	5	**	9	**	**
Improper starting or stopping	1	2	3	4	2	2	3	**	1	**	3
Operating at unsafe speed	1	**	1	**	**	1	1	**	**	4	1
Mak'g. safety dev. inoperative	**	**	1	**	**	**	**	**	**	0	0
No unsafe act	3	**	1	0	0	1	**	1	5	10	1
MECHANICAL CAUSE											
Total Cases	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Hazard, arrang. or procedure	64	72	78	77	67	72	82	51	52	34	68
Defective agencies	23	16	19	19	27	26	16	39	4	62	31
Unsafe dress or apparel	11	11	1	4	5	1	2	9	33	1	**
Improper ventilation	**	0	0	0	**	0	0	**	5	0	0
Improper guarding	**	1	1	**	1	**	**	**	1	**	0
Improper illumination	**	0	0	0	0	**	**	**	**	**	**
No mechanical cause	2	**	1	0	0	1	**	1	5	3	1
Number of Accidents	130,403	13,717	486	2,721	640	6,323	10,051	11,927	6,014	12,066	1,680

Courtesy National Safety Council.

Source: Pennsylvania Department of Labor and Industry. Classification of cases was made in accordance with the American Standard Code for Compiling Industrial Accident Causes.

* Includes agencies other than the ten for which detailed information is shown: pumps and prime movers, 398; boilers (pipe and pressure apparatus), 326; mechanical power transmission apparatus, 31; coal, 5,773; lumber or woodworking materials (not otherwise classified), 2,419; metal (plate, rod, sheet, etc.), 6.955; nails, 2,489; runways, stairways, scaffolds, etc., 376; objects not otherwise classified, 46,011.

** Less than half of one per cent.

TABLE 4

UNSAFE ACTS AND CAUSES OF PERMANENT DISABILITIES AND DEATHS, BY INDUSTRY

Unsafe Act or Cause	All Industries*		Machinery	Steel	Sheet Metal	Metal Products	Non-Ferrous Metals	Chemical	Paper & Pulp	Food	Public Utility	Construction
	Number	Percent										
UNSAFE ACT												
Total Accidents	3,112	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Unnecessary exposure to danger	796	25	25	27	20	21	31	24	31	29	22	30
Unsafe, or improper use of equip	467	15	19	15	21	13	13	11	17	7	12	12
Work'g on mov'g or dang. equip	428	14	13	15	13	12	9	18	14	19	12	9
Non-use pers. protective equip	275	9	7	9	6	7	9	7	6	4	20	9
Improper starting or stopping	284	9	12	8	3	12	10	9	8	7	9	13
Overloading, poor arranging	214	7	7	9	5	4	6	8	10	5	5	9
Mak'g safety devices inoperative	157	5	5	1	9	8	4	4	2	4	8	2
Operating at unsafe speed	93	3	7	2	3	4	2	3	3	5	2	5
No unsafe act	398	13	9	14	20	19	16	16	9	20	10	11
PERSONAL CAUSE												
Total Accidents	4,818	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Improper attitude	2,376	50	50	47	56	51	45	50	46	52	54	44
Lack of knowledge or skill	1,457	30	34	33	22	26	29	27	35	24	26	34
Bodily defects	102	2	1	2	1	2	2	2	3	3	2	4
No personal cause	883	18	15	18	21	21	24	21	16	21	18	18
MECHANICAL CAUSE												
Total Accidents	4,818	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Hazardous arrang. or procedure	1,634	34	33	41	26	27	36	35	40	28	30	41
Improper guarding	1,214	25	22	22	36	24	21	22	28	26	30	18
Defective agencies	747	15	14	15	14	16	20	18	16	17	15	21
Unsafe dress or apparel	277	6	5	5	6	6	8	5	3	5	8	7
Improper illumin., ventilation	32	1	1	1	**	**	**	1	**	2	1	2
No mechanical cause	914	19	25	16	18	27	15	19	13	22	16	11
Number of Accidents:												
Unsafe acts	3,112	..	564	244	200	187	202	214	208	182	453	187
Personal and mech. causes	4,818	..	800	449	295	303	291	355	360	262	707	243

Source: National Safety Council analysis of reports furnished by individual industrial establishments. Classification of cases was made in accordance with the American Standards Association code for compiling industrial accident causes. Larger numbers of reports are available for cause information than for unsafe acts merely because the cause data have been collected for a longer period of time.

* Includes information from industries other than the ten for which detailed information is shown.

** Less than half of one per cent.

TABLE 5

OCCUPATIONAL DISEASES*

	N. Y.	WIS.
All diseases	100%	100%
Dermatitis	47	59
Blisters & abrasions	15	*
Bursitis & synovitis	8	12
Benzol poisoning	5	†
Lead poisoning	5	3
Silica & dust	3	4
Compressed air disease	1	†
Other	16	22

Courtesy National Safety Council.

* Not listed by Wisconsin.
† Less than ½ per cent.

TABLE 6

TYPE OF ACCIDENT AND NATURE OF COMPENSATED INJURIES

Type of Accident	Total	Cuts, Lacerations	Bruises, Contusions	Strains and Sprains	Fractures	Burns and Scalds	Amputations	All Others
All Types	100.0%	29.1%	14.6%	22.2%	17.9%	4.5%	2.0%	9.7%
Handling objects	100.0%	23.6	11.6	43.6	13.5	0.1	0.9	6.7
Falls	100.0%	13.3	17.0	36.6	27.1	0.8	0.1	5.1
To a different level	100.0%	12.6	17.1	30.5	33.4	0.5	0.1	5.8
To the same level	100.0%	14.0	16.9	41.4	22.0	1.1	0.1	4.5
Machinery	100.0%	47.6	7.9	5.1	21.4	2.1	11.1	4.8
Elevators, hoists, conveyors	100.0%	31.6	13.7	7.2	36.1	0.5	5.8	5.1
Engines, power transmiss.	100.0%	31.6	6.6	11.7	20.7	10.9	7.6	10.9
Power-driven machinery	100.0%	51.4	5.7	4.5	13.1	1.9	13.7	9.7
Other machinery	100.0%	52.9	10.3	6.1	4.2	3.0	17.8	5.7
Vehicles	100.0%	24.9	17.4	20.0	26.8	0.7	1.4	8.8
Motor vehicles	100.0%	27.7	15.5	18.6	24.3	1.2	0.7	12.0
Other vehicles	100.0%	29.5	16.4	20.6	21.3	0.4	2.1	9.7
Falling objects	100.0%	41.8	16.5	4.2	30.6	0.2	1.0	5.7
Using hand tools	100.0%	60.2	10.5	7.0	10.8	1.0	1.4	9.1
Stepping on, striking object	100.0%	51.7	21.9	3.9	6.4	0.3	0.4	15.4
Electricity, explosives, heat	100.0%	7.1	1.3	0.5	2.6	82.0	0.4	6.1
Harmful substances	100.0%	1.4	0.1	0.2	0.2	47.8	0.1	50.2
All other types	100.0%	28.0	13.7	16.6	16.3	3.3	0.9	21.2

Courtesy National Safety Council.

Source: Reports from five State Labor Departments or Industrial Commissions: Idaho, Maryland, New York, Pennsylvania, and Wisconsin. Some details partially estimated.

TABLE 7

TYPE OF ACCIDENT, COMPENSATED OCCUPATIONAL INJURIES

Type of Accident	Percentage of Cases				Average Compensation per Case		
	Total Cases	Deaths and Permanent Totals	Permanent Partials	Temporaries	Total Cases*	Permanent Partials	Temporaries
Total	100.0%	100.0%	100.0%	100.0%	$265	$609	$88
Handling objects	24.3	5.6	20.9	25.3	159	411	79
Falls	18.1	15.9	16.2	18.6	338	897	122
To a different level	8.2	12.1	8.4	8.1	464	1,075	151
To the same level	9.9	3.8	7.8	10.5	231	705	102
Machinery	11.9	9.1	25.0	8.8	332	567	72
Elevators, hoists, conveyors	2.0	5.5	3.9	1.5	526	732	127
Engines, power transmission	0.7	0.5	1.3	0.6	365	714	73
Power-driven machinery	8.7	2.9	18.9	6.3	287	538	59
Other machinery	0.5	0.2	0.9	0.4	243	458	51
Vehicles	8.5	23.1	8.4	8.3	431	798	127
Motor vehicles	4.8	15.0	5.2	4.6	477	861	121
Other vehicles	3.7	8.1	3.2	3.7	376	702	134
Falling objects	10.4	18.1	8.4	10.8	318	605	114
Using hand tools	8.1	1.1	7.8	8.4	136	474	39
Stepping on or striking object	7.5	1.7	4.2	8.3	100	413	48
Electricity, explosives, heat	3.5	13.4	2.5	3.4	458	827	69
Harmful substances	2.7	4.3	1.1	3.3	230	781	83
Animals	0.6	0.3	0.5	0.7	245	863	65
Other types	4.4	7.4	5.0	4.1	295	528	74

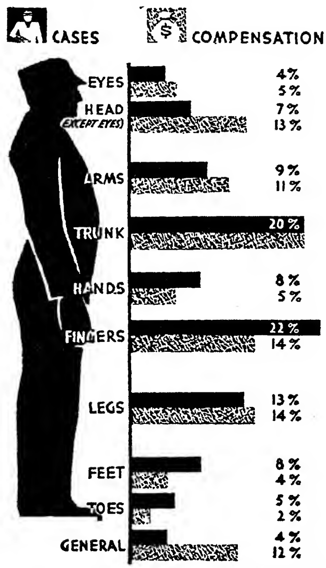
Courtesy National Safety Council.

Source: Percentage of cases, reports from eleven State Labor Departments or Industrial Commissions; average compensation per case, reports from eight State Labor Departments or Industrial Commissions.

* Compensation per case is not shown for deaths and permanent total disabilities because the average compensation ($4,930) is the same for all types of accidents. However, compensation for these cases has been included in the average compensation for all cases.

TABLE 8

DISTRIBUTION BY PART OF BODY INJURED



Courtesy National Safety Council.

REVIEW

1. Are available accident statistics satisfactory as a guide to preventive efforts? If not, why not?

2. Define "accident."

3. Why is it important to make a distinction between "accident" and "injury"?

4. Define "agency."

5. Define "accident type."

6. Define "unsafe act."

7. Define "unsafe mechanical or physical cause."

8. What in your opinion is the advantage of setting down in each instance both the unsafe physical cause (or causes) and the unsafe act (or acts), in so far as these are determinable?

9. Why does Heinrich in his study assign each injury to only one cause?

10. Can assigning an accident to carelessness ever give any information that will be helpful in preventing a recurrence?

CHAPTER VI

Analyzing Causes of Accidents

Whenever a worker is injured or whenever an accident occurs even though no one is injured, it is essential that the safety engineer or some other delegated person or group of persons in the firm analyze the accident from all possible angles so that intelligent action can be taken to prevent recurrence. This work is very much like that of a physician when called to see someone who is ill. The doctor seldom prescribes a remedy until he has examined the patient, analyzed all the symptoms, delved into the person's history, assembled all the facts, checked into all possibilities, and finally arrived at a proper diagnosis of the case. In a similar way, the safety engineer's work of analyzing the causes of accidents can be outlined in ten steps:

1. Secure the foreman's reports of the accident.
2. Secure the injured worker's report.
3. Secure the reports of witnesses.
4. Secure the report of the nurse or doctor.
5. Investigate the accident.
6. Record all the facts.
7. Tabulate the essential facts of the *given* accident together with those of *other* accidents.
8. Study all the facts.
9. Determine what action should be taken.
10. Assign responsibilities for carrying out the action decided upon.

Most of these steps are self-explanatory, therefore it is necessary to discuss only four of them in detail.

Recording circumstances surrounding an accident

When an accident occurs, it is necessary to record certain facts that may have to be reported to the state and insurance company. In addition, other facts should be recorded so that they can be considered when the accident is being investigated and when deciding what to do to prevent recurrence. Answers to such questions as the following are usually necessary for these purposes:

A. Who was injured:

Name.
Check number.
Address.
Sex.
Age.
Married.
Nationality.
Speak English.
Number children under 18.
Number dependent adults.
Weekly wage.
Occupation.
Years employed by company.
Present job.

B. Time and place of injury:

Date. Hour. Department.

C. Witnesses.

D. Nature and severity of injury:

Describe injury.
Name of physician.
His address.
Nondisabling.
Absence from work.
Started losing time.
Returned to work.
Actual days lost.
Time charges.
Permanent disability.
Part of body affected.
Percentage loss or loss of use.
Time charges.
Death.
Date of death.
Time charges.
Compensation costs.
Medical costs.
Other costs.

E. Agency of injury:

Machine, pump, prime mover.
Elevators and hoisting apparatus.
Conveyors.
Boilers (pipe and pressure apparatus).
Vehicles.
Transmission apparatus.
Electrical apparatus.
Hand tools.
Chemicals.
Other materials.
Other working surfaces.

F. What worker was doing.

G. Type of accident:

Fall of person—same level.
Fall of person—one level to another.
Slips (causing strains; not falls).
Falling, sliding, flying objects.
Caught in or between.
Struck against.
Drowning or immersion.
Burning or scalding.
Electric shock.

Inhalation, absorption, swallowing.
Poisoning.
Other types.

H. Unsafe act:

Operating without authority, failure to secure or warn.
Operating or working at unsafe speed.
Making safety devices inoperative.
Using unsafe equipment, hands instead of equipment, or equipment unsafely.
Unsafe loading, placing, mixing, combining, etc.
Taking unsafe position or posture.
Working on moving or dangerous equipment.
Distracting, teasing, abusing, startling, etc.
Failure to use safe attire or personal protective equipment.

I. Behavioristic cause:

Improper attitude (deliberate chance-taking, disregard of instructions, injured man knew how to do his job safely but he failed to follow safe procedure, absent-minded).
Lack of knowledge or skill (injured man did not know how to do his job safely, too new on the job, unpracticed, unskilled, etc.).
Physical or mental defect (one arm, deaf, epilepsy, partially blind, etc.).

J. Environmental cause:

Improper guarding (unguarded, inadequately guarded, guard removed by someone other than injured worker, etc.).
Substances or equipment defective through use or abuse (worn out, cracked, broken, etc., through no fault of injured worker).
Substances or equipment defective through design or construction (too large, too small, not strong enough, made with flaws, etc.).
Unsafe procedure (hazardous process, management failed to make adequate plans for safety).
Unsafe housekeeping facilities (unsuitable shelves, bins, racks, no aisle markings).
Improper illumination (poor, none, glaring headlights, etc.).
Improper ventilation (poor, dusty, gaseous, high humidity, etc.).
Improper dress or apparel (management failed to provide or specify use).

K. Foreman's explanation.

L. Foreman's recommendations.

M. Injured worker's explanation.

N. Injured worker's recommendations.

O. Injured worker's former injury record.

Tabulating facts

Part of the job of analyzing the circumstances surrounding a given accident is to tabulate the outstanding facts concerning *that*

accident, together with similar facts concerning *other* accidents. The following is a partial list of the facts worth tabulating:

1. Nationality.
2. Speak English.
3. Occupation.
4. Department.
5. Name of foreman.
6. Years employed by company.
7. Length of time on job.
8. Agency.
9. Type of accident.
10. Environmental cause.
11. Unsafe act.
12. Behavioristic cause.
13. Cost.
14. Time lost.

Such a tabulation is valuable for the following reasons:

1. When it is studied by the safety engineer, it may suggest to his mind certain preventive measures that might otherwise be overlooked.

2. It sometimes is difficult or impossible to secure immediate action on certain recommendations that are suggested for preventing the recurrence of a single accident. Tabulations of many accidents may provide cumulative evidence that such action is increasingly essential.

3. Tabulations clearly indicate the relative importance of certain facts and enable the safety engineer to select those machines, substances, hazards, causes, departments, foremen, workers, and other individuals on whom the safety engineer should concentrate more effort.

4. Such tabulations are used as a basis for accident prevention contests, for tracing trends, for determining if the accident record is getting better or worse, for preparing reports for executives, foremen, and workers, and for determining what preventive activities are most needed to secure the best results.

Studying the facts

It is essential for the safety engineer to study all the facts before deciding on the action that should be taken. Even though the accident may seem to be a simple one, and even though the necessary action may seem to be perfectly obvious, it is wise to go through the entire diagnosing procedure to make sure that nothing of value has been overlooked.

Prescribing remedies

After studying all of the facts, the safety engineer should start to jot down all possible things that might be done to prevent recurrence. If he follows this procedure, he will be surprised at the number of things he can think of that might be done. It may then

TABLE 9

ENVIRONMENTAL CAUSES OF ACCIDENTS, HOW TO ELIMINATE THEM, AND FUNCTIONAL RESPONSIBILITY FOR CORRECTIVE ACTION*

A	B	C
Environmental Causes of Accidents:	How to Eliminate the Causes of Accidents; Suggestions for Corrective Action:	Who Can Eliminate the Causes; Functional Responsibility for Corrective Action in a Typical Plant:
1. Improper guarding (unguarded, inadequately guarded, guard removed by someone other than injured worker, etc.).	a. Inspection. b. Checking plans, blueprints, purchase orders, and contracts for safety. c. Include guards in original design, order, and contract. d. Provide guards for existing hazards.	a. Safety director, foreman, and maintenance man. b. Chief engineer and purchasing agent. c. Chief engineer and purchasing agent. d. Maintenance man and foreman.
2. Substances or equipment defective through use or abuse (worn out, cracked, broken, etc. through no fault of injured worker).	a. Inspection. b. Proper maintenance.	a. Safety director, foreman, and maintenance man. b. Maintenance man.
3. Substances or equipment defective through design or construction (too large, too small, not strong enough, made with flaws, etc.).	a. Source of supply must be reliable. b. Inspection for defects in plans and materials. c. Correction of defects.	a. Purchasing agent. b. Chief engineer. c. Chief engineer.
4. Unsafe procedure (hazardous process, management failed to make adequate plans for safety).	a. Job analysis. b. Formulation of safe procedure. c. Job training.	a. Production manager. b. Production manager and foreman. c. Foreman.
5. Unsafe housekeeping facilities (unsuitable shelves, bins, racks; no aisle markings, etc.).	a. Provide suitable layout and equipment necessary for good housekeeping.	a. Chief engineer, production manager, and foreman.
6. Improper illumination (poor, none, glaring headlights, etc.).	a. Improve the illumination.	a. Chief engineer and production manager.
7. Improper ventilation (poor, dusty, gaseous, high humidity, etc.).	a. Improve the ventilation.	a. Chief engineer and production manager.
8. Improper dress or apparel (management's failure to provide or specify use).	a. Provide safe dress or apparel or personnel protective equipment if management could reasonably be expected to provide it. b. Specify the use of certain protective equipment on certain jobs.	a. Plant manager. b. Plant manager.

* *Courtesy* Lumbermen's Mutual Casualty Company.

become difficult for him to decide which of these suggestions, if any, he should discard, and which he should write up in recommendation form for official approval and follow-through.

When endeavoring to prescribe remedies, the safety engineer will frequently derive many especially valuable ideas from his

TABLE 10

BEHAVIORISTIC CAUSES OF ACCIDENTS, HOW TO ELIMINATE THEM, AND FUNCTIONAL RESPONSIBILITY FOR CORRECTIVE ACTION*

A	B	C
Behavioristic Causes of Accidents:	How to Eliminate These Causes of Accidents; Suggestions for Corrective Action:	Who Can Eliminate These Causes; Functional Responsibility for Corrective Action in a Typical Plant:
1. Improper attitude (deliberate chance-taking, disregard of instructions, injured man knew how to do his job safely but failed to follow safe procedure; absent-minded, etc.).	a. Supervision. b. Discipline. c. Personnel work.	a. Foreman. b. Foreman and personnel man. c. Personnel man.
2. Lack of knowledge or skill (injured man did not know how to do his job safely, too new on the job, unpracticed, unskilled, etc.).	a. Job analysis. b. Job training.	a. Production manager and foreman. b. Foreman.
3. Physical or mental defect (one arm, deaf, epilepsy, partially blind, etc.).	a. Pre-employment. Physical examinations. b. Periodic physical examinations. c. Proper placement of men.	a. Physician. b. Physician. c. Physician and personnel man.

* *Courtesy* Lumbermen's Mutual Casualty Company.

study of the behavioristic and environmental causes listed, under *I* and *J*, particularly if two other columns are added to these lists (see Tables 9 and 10), one column indicating suggested remedies, the other indicating the functional responsibilities for putting these suggestions into force.

Examples. Let us consider briefly a few actual accident cases.

Case 1. A worker who had been six years on the job as machine operator "slipped" on the concrete floor and caught his hand in a set of improperly guarded gears, losing 3 fingers. There was nothing on the floor to cause him to slip.

Cause: Improperly guarded machine.
Suggested action: Completely enclose gears.
Persons to carry out suggestion: Chief engineer and maintenance man.

Case 2. A crane chain in service an unknown number of years broke and dropped a load, crushing the toes of a worker. The chain was of proper size for the load. The employer did not encourage or require workers to wear safety shoes.

Causes:
1. Equipment defective through use.
2. Improper apparel.

Suggested action:
1. Institute program for periodic inspection of all crane chains and see that defective chains are destroyed or made safe.
2. Specify that workers on certain jobs must wear safety shoes.

Persons to carry out suggestions:
1. Chief engineer.
2. Plant manager.

Case 3. A worker three years on the job was running down stairs; he stumbled and fell, breaking an arm. The stairs were well lighted, in good condition, and provided with hand rails on both sides. All workers had been cautioned not to run in the mill, particularly when going up or down stairs.

Cause: Wrong attitude.
Suggested action:
1. Determine reason for running and correct by disciplinary action if necessary.
2. Repeat caution to all workers.
3. Tighten up on supervision.

Persons to carry out suggestions:
1. Worker's foreman.
2. Plant manager and foremen.
3. Plant manager and foremen.

Case 4. A man was assigned to operate a drill press. On the first day of work he wore gloves; his glove caught on the drill and two of his fingers were broken.

Cause: Lack of knowledge. Did not understand danger of wearing gloves when operating drill press.
Suggested action: Improve job training and supervision.
Person to carry out suggestion: Foreman.

Case 5. An oiler, after entering a room where oil was stored, slipped on oil on the floor, fell, and sprained his wrist. One oil faucet had been leaking for several days. No one had cleaned up the oil from the floor.

Causes:
1. Equipment defective through use.
2. Unsafe housekeeping facilities.
3. Improper attitude.

Suggested action:
1. Inspect and repair leaky faucets.
2. Provide drip pan to catch oil in case of leakage.
3. Supervise and discipline oilers.

Persons to carry out suggestions:
1. Foreman.
2. Foreman.
3. Foreman.

REVIEW

1. What is the purpose of analyzing accidents?

2. Should every accident be analyzed in detail?

3. Why is the work involved in tabulating accident facts justified?

4. What step should follow the analysis of each accident if the analysis is to be of value?

5. What final step is necessary to assure the proper corrective action?

CHAPTER VII

Fundamentals of Accident Prevention

It is generally agreed that accidents are caused—they don't simply happen; and the way to prevent accidents is to discover and eliminate accident causes.

On the basis of these facts it is not too difficult to outline at least a few of the fundamentals of accident prevention.

Controlling the causes of accidents

The three E's for safety, representing engineering, education, and enforcement, stand for the generally accepted means of preventing accidents on the streets and highways. The same means of prevention apply to some extent in the field of industrial safety, but it seems much easier to comprehend the fundamentals of industrial accident prevention if the preventive procedures are grouped in four general classifications that are a little more self-descriptive and that fit the problems a little more closely than do the three E's. These four classifications are:

1. Discover causes.
2. Control environmental causes.
3. Control behavioristic causes.
4. Supplementary activities.

Discovering accident causes. Before any steps can be taken to prevent accidents, it is essential to discover:

1. The causes of previous accidents.
2. The existing hazards that *will* cause accidents unless corrected.

Thus it is essential to:

1. Investigate all accidents.
2. Record and tabulate all facts concerning each accident.
3. Analyze the records and tabulations.
4. Inspect all company property and equipment.

These activities are necessary not only before starting the actual procedures of accident prevention, but also afterward, for they must be given continuous, never-ending attention. Otherwise, the real effort of accident prevention will get out of hand, there will be entirely too much lost motion, and attention will not be concentrated in the right direction.

Controlling environmental causes. From Table 9 in the preceding chapter it is seen that there are eight environmental causes of accidents. In Column *B* of that table are listed thirteen means of control:

1. Check plans, blueprints, purchase orders, and contracts for safety.
2. Include guards in original design, orders, and contracts.
3. Provide guards for existing hazards.
4. Proper maintenance.
5. Sources of supply must be reliable.
6. Inspection for defects in plans and materials.
7. Correction of defects.
8. Formulation of safe procedures.
9. Provide suitable layout and equipment necessary for good housekeeping.
10. Improve the illumination.
11. Improve the ventilation.
12. Provide safe dress or apparel or personal protective equipment if management can reasonably be expected to provide it.
13. Specify the use of certain protective equipment on certain jobs.

It is noteworthy that (a) all of the environmental causes have to do with machinery and equipment—with *things* that one can see or feel; and (b) the control procedures have to do with engineering—or rather with the application of engineering principles.

In some respects, the control of environmental causes (or hazards) is the most essential factor in any accident-prevention program. First, it proves to the workers that the management is sincere in its desire to prevent accidents and is willing to do its part. In addition, if there are two or more different ways to prevent certain types of accidents, this way is preferable. For example: If there is a hole in the floor, and if there is danger of workers falling into it and being injured, it is much wiser and cheaper in the long run to eliminate the hole than it is to place a guard rail around it or to try to teach workers to stay away. Trying to teach men to avoid a hazard is a never-ending job

requiring constant supervision, and in some cases discipline; but the elimination of a hazard is an immediate and a permanent cure.

Controlling behavioristic causes. The three behavioristic causes of accidents listed in Table 10 can be controlled largely by the following seven activities:

1. Job analysis.
2. Job training.
3. Supervision.
4. Discipline.
5. Personnel work.
6. Physical examinations.
7. Proper placement of workers.

In general, it is much more difficult to control behavioristic causes than it is to control environmental causes. Unlike environment, human behavior is without substance; it can neither be seen nor felt. It is the result of many complicated factors, as heredity, emotions, diet, and habits. Therefore it is not surprising that the methods of control are somewhat complicated; they are not exact sciences as are various fundamentals of engineering, such as mathematics, physics, and chemistry.

For example, wrong attitude is an important behavioristic cause that is frequently induced by worry. Many workers worry about current financial problems, or about the possibility of poverty in old age, or the expense of medical care. In many organizations, personnel activities have been instituted such as pension plans, group health and accident insurance, and employees' credit unions that have helped to relieve thousands of workers of some of their most worrisome problems, and thus have helped to improve the firms' accident records.

Supplementary activities. In addition to the essential procedures already outlined in this chapter, there is another group of supplementary activities. Among these are:

1. Rule books.
2. Posters.
3. Booklets; other literature.
4. Movies.
5. Film strips.
6. Contests.
7. Meetings.
8. Committees.
9. Suggestion systems.
10. Employee magazines.

These activities are of secondary importance when compared with other procedures; they are not aimed directly at the discovery and elimination of accident causes. But they are particularly valuable in arousing and maintaining interest in safety. It should be pointed out, however, that it is not advisable to undertake all of these supplementary activities simultaneously. No attempt can be made to suggest their relative importance, for this varies

in different establishments, depending upon such factors as existing conditions, personalities of executives, and needs of the moment.

Responsibility for safety

We have tried in the preceding part of this chapter to outline the answers to the questions, "*What* should be done?" and "*Why?*" Let us now turn to the question, "*Who* is responsible?"

From Tables 9 and 10 in the preceding chapter it is apparent that the following individuals must carry the major responsibility for applying the corrective measures that will prevent accidents:

1. Plant manager.
2. Production manager.
3. Chief engineer.
4. Purchasing agent.
5. Physician.
6. Personnel man.
7. Maintenance man.
8. Individual foremen.
9. Safety director.

These are not the only persons, however, who have responsibility for accident prevention. In the final analysis, every person in the outfit must carry a certain share of the responsibility; even the lowliest laborer must carry out instructions and see to it that neither he nor any of his fellow workers are injured through an unsafe act that may be ascribed to his "carelessness."

Looking at it from one point of view, it is unfortunate that the responsibility for preventing accidents must be shared by so many individuals; for usually "everybody's job is nobody's job." Each person is too likely to assume that "the other fellows are doing their part and it will never be noticed if I fail to carry my share of the burden."

Management must provide leadership

Under the circumstances, therefore, it is absolutely essential that top management as a whole, and the chief operating executive in particular, provide the same kind of leadership in accident prevention as they provide in the field of production. If the manager becomes convinced that accidents can and must be prevented, he will issue the necessary orders that are to be carried down through the organization; he will follow through to see that his orders are carried out; he will set a good example for safety; he will do everything in his power to provide a safe environment in which to work; and he will see to it that his assistants do their best to control the behavior of the workers. Without this leadership, the accident-prevention effort in his establishment is bound to become a hit-and-miss affair, and thus it will fall far short of maximum results.

The safety director

A safety director should be appointed in every establishment, regardless of its size and nature of business, and even though the degree of hazard may seem to be relatively unimportant. In smaller establishments, the safety director need not devote his entire time to safety, but under no circumstances should this assignment be given to a person who is already overloaded with other duties.

Frequently, the appointment of a safety director is accepted by department heads and supervisors as a welcome relief from all responsibility for safety. In their opinion, the safety director will do all of the things that are necessary for the success of the accident-prevention effort. They do not realize that no matter how capable the safety director may be, he can never be expected to perform the entire safety job singlehandedly. Especially he cannot perform satisfactorily the functions discussed earlier in this chapter under the headings "Controlling Environmental Causes" and "Controlling Behavioristic Causes." For example, no one can so effectively supervise the workers as the foreman; no one other than a doctor should make physical examinations of the workers; no safety director can be expected to design suitable ventilation installations as well as can selected members of the engineering department.

The question might then well be asked, "If department heads and supervisors are required to do so much of the accident-prevention job, what are the duties of the safety director?" It is hardly necessary at this point to give a complete answer to this question, but the following list suggests some of the safety director's major responsibilities:

1. *Statistician:* Maintain and analyze accident records.
2. *Investigator:* Assist staff personnel and supervisory executives in investigating all accidents and near accidents.
3. *Inspector:* Assist others in making inspections to discover accident hazards.
4. *Salesman:* "Sell" the idea of safety to every person in the outfit; influence each individual to accept his share of the responsibility for preventing accidents.
5. *Advertiser:* Keep everyone informed concerning (a) the progress that is being made, and (b) the Accident problems that need further concentration of effort.
6. *Secretary:* Serve as secretary for safety committees and for other functions.

7. *Planner:* Watch and plan for the continued progress of the safety program.
8. *Safety Technician:* Keep technically up to date.

Under no circumstances should the safety director attempt to assume any of the duties or responsibilities that rightfully belong to others in the organization. In fact, if every official, every supervisor, and every worker, would do his full safety duty, there would be no accidents and safety engineering would become an obsolete profession.

The foreman

Foremen individually and collectively carry a greater share of the responsibility for accident prevention than any other one person or group of persons—with the possible exception of the manager. For one thing, they are close to the workers, the persons who usually get hurt in accidents. Then too, the foremen are to a great degree responsible for the mishaps that occur in their departments; they stand between management and workers, issuing, interpreting, and enforcing orders, and carrying out the management's policies. They are usually selected from the ranks to serve as foremen because of their special skills or qualities of leadership. Thus they are in a particularly strategic position to win the workers' confidence and respect, not only for themselves as foremen, but also for the management and the firm they represent.

In addition to their leadership among the workers, foremen also have the opportunity to help in controlling environment. Each foreman makes at least several tours daily through his department, and if he has the right attitude toward safety he will almost subconsciously observe hazards, such as damaged or misplaced guards, unsafe ladders, defective tools, and poorly adjusted machines. He thus can speed up the corrective measures that must be taken.

In general, it is essential that every foreman should understand the importance of the position he occupies in the safety setup of his firm.

REVIEW

1. In what four groups are the fundamentals of accident prevention classified?

2. What four steps are necessary to discover accident causes?

3. What are the thirteen means of control of environmental causes?

4. Why should the control of environmental causes be placed ahead of the control of behavioristic causes?

5. What seven activities are required to control behavioristic causes?

6. Why are behavioristic causes more difficult to control than environmental causes?

7. List ten supplementary activities that are useful in arousing and maintaining interest in safety.

8. Upon what individuals must major responsibility for safety rest?

9. What part must the chief operating executive in any establishment take?

10. What are the functions of the safety director?

CHAPTER VIII

Job Safety Analysis

Job analysis is an essential part of production control and as such its technique has become well developed and widely established in American manufacturing practice. It involves the accurate and detailed description of each job in terms of duties, tools required, methods, sequence of operations, and working conditions. As would be expected, such a procedure of itself eliminates a high proportion of accident hazards. When, to adequate job analysis, the other necessary factors of successful mass production are added, namely, planning, supervision, training, and continuous control, we get a high degree of safety as an inherent part (we might say as "a by-product") of quantity production. Production is not efficient unless it is safe. If this fact were fully appreciated by management generally, it would widen tremendously managerial interest in accident elimination.

The safety man's knowledge of job analysis need not include all the steps in mass production technique, but he should be reasonably familiar with the procedures involved in order to concentrate on the prevention of accidents in a manner that will be practical and of maximum effectiveness. While he should not accept the jobs that have been placed under "production control" as free from fault, the major part of his effort will be required on those that have not been so placed.

Not only could industry profitably extend the application of job analysis much more widely to repetitive types of work in general, but similar methods should be applied generally to non-repetitive work, such as maintenance and short-order production. It is the general experience that this type of work shows a relatively bad accident record. Presumably, this is chiefly due to two factors, namely, relatively high hazard together with the lack of detailed analysis and control.

An example of the value of the application of job analysis is given by the record of one large firm. It had over a period of years brought its frequency rate down from over 50 to under 10, where it hovered between 7 and 10 for several years. Detailed study showed a frequency rate under 5 for all production work

(job analysis had been applied to nearly all of this) with most of the short-order production jobs and maintenance, material handling and incidental construction work showing frequency rates up to 30 or even above. By extending job analysis procedure to most of these activities, their frequency rate was cut by from 50 to 90 per cent and the overall frequency rate was brought under 5 for the first time in the company's experience. This and other examples appear to justify the conclusion that, if similar procedure were widely followed, a major advance would be scored in the fight to eliminate accidents.

Job analysis includes details of operations

Job analysis or job breakdown requires getting down to the minute details involving all the operations of a job. A detailed description of each step from the time the work is started should include the preliminaries of issuing the job tickets, blueprints, and special tools, as well as definition of the skill and other qualifications required for the job.

Selection of employees

This part completed, the manufacturing department is in a position to inform the personnel department what help is required, so that the proper selection may be made at the employment office. If the operations are broken down properly, it is a comparatively simple matter to decide what personal characteristics are necessary in the new employees, such as age, sex, health, education, physique, skill, height, and weight.

It would be undesirable and hazardous to place a 100-pound girl, 5 feet tall, on a punch press which required a person 5 feet, 6 inches, at least, to reach over far enough to place the work properly. Then, too, if the parts are too heavy for a 100-pound girl, fatigue, as well as extra straining due to inadequate reach, would decrease efficiency and increase the hazard of injury.

After the manufacturing department has analyzed the job, it is ready to inform the employment man what to look for in a prospective employee. The request for help would read, for example:

Request for 1 Operator on Large Punch Press, Class A

Occupations Most Nearly Allied Are:
Hydraulic press operator.
Weidemann press operator.
Shear man.

Trade Requirements:

Set up and operate punch presses. Must be able to make set-ups with standard dies; do all types of punch press work within the capacity of the machine. Work from blueprints.

Education—Common school or better.

Physical Requirements:

Weight	140 lbs.
Height	5′6″ minimum.
Age	21 years minimum.

Average strength.
Standing job.
Satisfied with repetitive work.

Rate Established—Piece Work.

Importance of proper instruction

Proper selection of the new employee to suit the requirements of the job is essential. It is at least as important that he receive his instruction and training from an instructor or supervisor who can teach effectively and who has the individual steps in such

JOB BREAKDOWN SHEET FOR TRAINING MAN ON NEW JOB

Part: Shaft — Operation: In-feed Grind or Centerless Grinding

Important Steps in the Operation	Keypoints—knacks—hazards, feel, timing, special information
1. Place piece on plate against regulating wheel	"Knack"—don't catch on wheel
2. Lower lever—feed	Hold at end of stroke (count 1-2-3-4) slow feed—where might taper-watch-no oval grinding
3. Raise level release	
4. Gauge pieces periodically	More often as approach tolerance
5. Readjust regulating wheel as required	Watch—no backlash
6. Repeat above until finished	
7. Check	

instruction well planned and organized for the purpose. Much too often the supervisor who thinks he knows the job perfectly fails as an instructor because he does not look at the job from the viewpoint of the new worker. The job breakdown sheet will greatly aid this type of supervisor to correct this weakness; even the most experienced and effective of supervisors will find it

helpful in organizing operations in proper sequence so that the operator will be able to grasp them more readily and learn to perform his work better, faster, more safely, and with a minimum of supervision and follow-up.

Breaking the job down into its component parts

A simple job breakdown sheet for training new men can be made quickly for almost any job. The sample on page 71 for centerless grinding is typical.

A simple job such as driving a screw can be analyzed thus:

JOB BREAKDOWN SHEET FOR TRAINING MAN ON NEW JOB

Part: Door Hinge — Operation: Drive Wood Screw (Yankee screw driver)

Important Steps in the Operation	"Key Points"—knacks, hazards, "feel," timing, special information
1. Set screw driver at R. "fixed" position	
2. Center bit in screw head	
3. Start screw	Steady screw with fingers. Enough pressure to start. Hold vertically—don't let bit jump out of screw head
4. Set screw driver at R. ratchet position	Slips injure work and fingers
5. Center bit in screw head	
6. Drive screw	Hold bit squarely in screw. Operate vertically. Keep pressure on screw
7. Finish drive	Drive at "closed" position. Extra pressure—even—vertical. Don't let bit jump out. Set driver at "fixed" position if necessary. Solid tight finish—don't split screw

It is generally accepted that 80 per cent of most jobs are very simple operations, which any average person can perform with a minimum of training. The balance, or 20 per cent, represent the knacks or skills and tricks of the trade which come through training and experience. These critical or key points must be made clear and emphasized more than are the regular steps in the operation. At the same time, of course, accident hazards are stressed.

Naturally, there are some nonrepetitive jobs, such as maintenance and repair work, but even these can be analyzed so that a fairly regular sequence can be followed.

The routine versus the nonrepetitive job

R. P. Blake gives the following typical example showing the differences between a routine and a nonroutine job:

> In lieu of the routinizing of motions involved in quantity production jobs, stress in nonrepetitive work is on the training of the workmen in safe ways of performing specific operations as lifting, using tools, etc. That is, in planning for and laying out the job, the different operations involved are described and men with the requisite training in them are specified. A comparison between a typical production job and a typical maintenance operation will make the need for this course clearer.

Production job (1 operator)	*Maintenance job* (Mechanic and Assistant)
Part #2A42 Operation #4	Rebabbitt main bearings mill #47
A. Pick up piece from pan with left hand, place in jig, lock jig.	A. Obtain required tools, equipment and supplies from tool and stock room including safety equipment required.
B. Slide jig under first spindle, drill 2 #40 holes.	B. Clear with department superintendent and foreman and arrange for coöperation necessary to control hazards that might be involved.
C. Slide jig under second spindle, drill 1 #48 hole, turn jig over, drill 2 #48 holes.	C. Set up screens, barriers, warning signs, etc., as needed to protect other workmen and prevent interference with job.
D. Turn jig over, unlock jig, remove finished piece and place in pan for finished work.	D. Go over layout of job in detail with assistant to insure full understanding of procedure and requirements of each part of job.
E. Brush chips from table and jig.	

In planning and setting up the production job, the following provisions should be made for safety:

1. Comfortable seat with proper height relation to table.
2. Chip hopper under or at back of table with grating section in table located for convenience in brushing chips to and through it; suitable brush to be used.
3. Spindles pulled down to working position by hand levers. Spindles and drills enclosed in telescoping cylindrical metal guards arranged to contain drills fully in their raised position and allowing only sufficient projection of drill, when drill is lowered, to permit proper placing of hole.
4. All moving power transmission parts fully enclosed.
5. Machine controls conveniently located and protected against accidental contact.
6. Provide lighting of adequate intensity free from shadows or glare.

The hazards usually present in the maintenance job are:

1. Interference with adjacent operations.
2. Contact with adjacent machines or equipment.
3. Falls in setting up and removing hoisting rig or in working on scaffold or machine frame, etc. (large machine), or from tripping over loose material or from slippery footing due to oil spillage.
4. Flying particles.
5. Hand tool hazards.
6. Those connected with the lifting, hoisting, moving, and placing of mill parts.
7. Explosions of babbitt due to failure to guard adequately against the presence of moisture.
8. Burns.
9. Electric shock or burns if electric powered tools or extension lights are used.

In planning for and laying out the babbitting job, each of the hazards listed will suggest detailed precautions which should be taken. Tools and equipment should be of a proper type and properly maintained; the protective equipment used should be in accordance with good practices; the mechanic and his assistant should be properly trained and instructed; and supervision should be adequate.

Such work as oiling machinery, washing windows, cleaning, painting, etc., involving exposure to a wide variety of hazards, is particularly apt not to be carefully planned or adequately supervised. The slogan, "Follow the oiler," often used by safety men, expresses this fact. It is not necessary and it may not be desirable to routinize such work in great degree. However, it is highly important from a safety standpoint to analyze these jobs adequately. Proper analysis will determine exactly what hazards are involved and will indicate correct control measures. With these things settled, the instruction and training required can be definitely set forth and provided for, together, of course, with all equipment, tools, and safety devices needed.

Safety benefits from analysis

The benefits of job analysis are multitudinous and affect production as well as safe operation. From a safety viewpoint, the advantages are:

1. Discovery of existent physical hazards.
2. Discovery and elimination or safeguarding of motions, positions, or actions that are hazardous.
3. Determination of the qualifications required for the safe performance of the work, such as physical fitness, motor skills, special abilities, and so on.
4. Determination of equipment and tools needed for safety.
5. Establishment of standards needed for safety, including instruction and training of workmen.
6. Proper organization of methods consistent with accepted efficient and safe practices.

7. Preplanning, preparedness, proper performance started by organizing the mind to execute properly the requirements of the operations.

Training new employees

In applying the principals of accident prevention, it is sometimes found better to train an inexperienced individual rather than break up an accumulation of bad habits or practices acquired over a period of time. Sometimes employees are inherently unsuited to the work they are expected to perform. If a job study has been made, it will indicate the characteristics to look for in the men such as strength, height, weight, skill, judgment of distance, speed of hand or eye, versatility, perseverance, and special physical or other qualities.

Added to this, the details of the operations will bring out specific hazards so that in the training process they may be made known and full instructions given on how to avoid injury.

Special cognizance must be given to the fact that a man transferred to a new job may be on a par with a new man; in other words, he may be oriented to the factory but not to his new work. This may mean correcting habits acquired in another department which may be hazardous on the new job. The old story of having done this work this way for ten years and never had an accident before is too often heard.

Maintenance and other nonrepetitive work

On repetitive work, if the initial planning is carefully considered, the work goes on smoothly and safely. On nonrepetitive work such as repair or maintenance, a general system of planning each job increases the efficiency, speed, and safety of the irregular activities.

For example, general safe practices in maintenance work should include:

1. Use of proper tools for specific tasks.
2. Planning for proper headroom while working.
3. Placing tools convenient for reaching.
4. Keeping tools in A-1 condition.
5. Prevention of reaching over moving equipment by establishing a rule to stop all machinery before starting to work and locking out or tagging the switch.
6. Avoiding off-balance positions while on ladders or above the floor level.

7. Correct positions for lifting.
8. Consideration of other workmen and hazards to others.

Taking machines apart for repairs requires a regular routine for each kind of machine, which can be analyzed and planned just as a routine production job is. The difference lies in the additional number of operations involved because of the nonrepetitive nature. This calls for a larger number of breakdown sheets.

New man benefited by job study

Careful analysis presupposes:

1. Having a plan.
2. (a) Analyzing the job by breaking it down to the principal steps and listing them. (b) Picking out the key points or knacks to emphasize special action in connection with the principal steps.
3. Having the right tools, equipment, and materials specified.
4. Having the work place properly arranged.

After the above details are carefully worked out, we are ready for the new man. Put him at ease, find out what he knows, and get him interested in the new job.

The next step is the presentation of the operations by:

1. Telling, showing, illustrating, and questioning to make certain your points are understood.
2. Stressing the important parts or knacks with emphasis on the safe way.
3. Giving clear and complete instructions, taking up one point at a time and no more than the new man can master. Drive your points home before proceeding.
4. Check up on what he is learning by asking questions.

After this, the new man is ready to perform the job and to tell and show the instructor how it should be done. The instructor observes carefully, corrects errors, and repeats instructions if necessary. If the learner shows promise, he is put on his own; but he should be followed up and checked until he has proved that he is qualified to work efficiently and safely.

The following of this careful routine is of great value; because thus a person may be trained to do a job right and to utilize methods which experience has proved to be the best and safest.

On-the-job safety analysis

In the preceding paragraphs, we have dealt with the foreman's part in carrying on production. The safety man does not as a

rule participate in this analysis before the new job is started, and it is, therefore, necessary for him to do his part by observing the operations of the man on the job. On-the-job safety analysis is a measuring stick by which the effectiveness of an operation in the shop may be judged with reference to safety and efficiency. We are then observing the movements of the worker with relation to the performance of each cycle in the task.

The safety man in the shop will start by observing closely the movements of the worker. As the movement pattern becomes clear, he can pick out those movements that might be hazardous and eliminate them or provide adequate safety devices.

As an example, take a crimping operation performed on a punch press. The part is placed into the nest of the die with the right hand. Using hand trips located on each side of the press, both hands are out of danger because they are required to trip the press.

The press performs the operation and the operator reaches under the die with the left hand to get the crimped part and places it in a tote box on the floor. Since the left hand is placed between the dies to get the finished piece, there is a hazard, because the hand could be amputated if for some reason the press repeated or was tripped. This potential hazard can only be recognized by observing the movements of the operator with reference to the equipment. Bear in mind that we also have another hazard because we load by hand.

Applying our "on-the-job analysis," we can decide to use a mechanical ejector or air ejector to get the piece out and drop or blow it into a chute, which will carry it to the tote box on the floor.

Then, reviewing the method of feeding to remove hazard number two, we can decide to substitute for the use of hands, for placing the work on the die, by using a metal chute outside of a *guarded* die so that the work will slide into the die nest by gravity or mechanical feed.

With this improved set-up, we accomplish:

1. A guard completely encloses the die.
2. Neither hand is required to go into the danger zone.
3. A foot trip is substituted for the two hand trips.
4. The operation is simpler, faster, hence less costly.

The change-over costs are relatively low and are soon offset by the saving in time, to say nothing of the potential losses due to accident. This same method could be used on flattening operations. Other simple methods could be applied to meet the various conditions to be found on punch presses and all other machines.

The question may be asked, "Why didn't this hazard show up when the foreman analyzed the job?"

Every safety man knows that millions of jobs are in our shops now that were never analyzed. If a systematic analytical process were established in a shop to do one or two jobs a day in every department, the dividends would be enormous.

Management realizes that job breakdown or job analysis pays dividends not only in efficiency but also in preventing injury and keeping men on the job and machines and equipment in operation.

A good safety man appreciates the present situation and considers "on-the-job analysis" one of his most effective means of eliminating accidents.

REVIEW

1. What is meant by job analysis?

2. How does job analysis assist in selection of employees?

3. How does job analysis assist the instructor of employees?

4. Explain the difference between important steps in an operation and the key steps or key points.

5. How does the analysis of a job assist in safety?

6. What are the benefits of job analysis to the new employee?

7. Analyze the job of drilling a quarter-inch hole in a piece of copper one-half inch by one inch by two inches, the hole to go through the center of the piece, through the part one-half inch thick.

8. Explain the difference between job analysis as done by the foreman and on-the-job analysis as done by the safety engineer.

CHAPTER IX

Plant Inspection

As was previously pointed out, accidents do not just happen; they definitely are caused by unsafe conditions or unsafe practices in combination or singly. It is obvious, then, that if we are to prevent accidents (and the human injuries they yield), we must discover the causative factors and apply adequate corrective measures before the accidents occur. Well-planned inspection procedure thoroughly and systematically applied is an effective means of discovering hazardous conditions.

We all know that on the average a very considerable amount of time must be expended after each accident merely to restore satisfactory operation. A moderate amount of paid-for time is consumed in the maintenance of an adequate inspection service, but whatever it may cost in time and money to discover the hazards in advance of the accidents is much less than (usually only a small fraction of) the cost of discovering each hazard by the accidents it will inevitably bring if left uncorrected.

A simple and commonly recurrent type of accident is exemplified by empty drums insecurely piled and finally rolling down onto a man working near by. The injury was sustained at a definite moment, immediately following the collapse of the pile, but the possibility of injury was created when the drums were piled, which might have been hours, days, weeks, or even months before they actually fell.

Adequate planning, instruction, training, and supervision would obviously prevent the creation of such hazards as that cited above, but even the best performance in these respects is powerfully aided by an effective safety-inspection service. Well-planned systematic inspection by competent personnel will discover almost all hazardous conditions promptly upon their development, and will often anticipate them. Such inspection can also be helpful in discovering unsafe practices and procedures, though, for the most part, these are found and corrected chiefly through supervision and training procedures, job analysis, and the coöperative efforts and suggestions of the workmen themselves.

Two types of safety inspection are commonly made use of:

1. The essentially one-call inspection to appraise safety conditions and safety performance in a plant. This is usually the function of an insurance engineer, a state or other governmental safety inspector, or a consultant who calls at the request, or at least with the approval, of the management.

2. A continuing activity set up and maintained by the management to discover conditions and, so far as practicable, procedures and practices that, if uncorrected, may or will cause accidents.

The one-call type of inspection

It is assumed that the purpose of the visit is to make an appraisal of the safety performance of the plant or undertaking in question and present the facts thus gained to the management for use in improving performance. As already pointed out, management (including all those in a supervisory capacity) must believe in safety, understand and apply safety principles, and insist on safe practice throughout the plant if good safety performance is to be reached and maintained. Since this is true, not only must the safety appraiser reach correct conclusions, but he must also present them effectively. That is, he must be a salesman as well as an engineer. He should not be a "high-pressure" salesman, more concerned with the effect of his salestalk than with its reliability, but a sales engineer who deals only with facts and sound conclusions drawn therefrom and who makes every effort to so present his findings as to make them of maximum value as well as stimulative of adequate corrective action.

In so far as is practicable, the inspector-appraiser should, just as a salesman does, get as much advance information pertinent to his mission as he can. Such matters as type of industry, size of establishment, size and standing of company, its position in the community, its organizational setup, its safety record, and the personality of its chief operating executive are all likely to be of value, though any of this advance information may need to be revised in the light of the findings during the visit. Since the time available for the appraisal is usually limited, every moment should be carefully spent. The inspector should plan his work as far as possible, but at the very least he should set down in orderly form the conditions, factors, and matters that should definitely be investigated.

R. P. Blake recommends the use of check lists[1] of items that

[1] Industrial Safety Subjects, U. S. Department of Labor, Division of Labor Standards, Washington, D. C.

should be looked into. Each inspector should make up his own lists to suit his own needs and methods, for such lists serve as a safeguard against memory lapses and oversight. He suggests the following as a foundation list:

1. Housekeeping.
2. Material handling methods.
3. Adequacy of aisle space and working space.
4. Guarding of transmission machinery.
5. Point-of-operation guards.
6. Maintenance.
7. Hand tools.
8. Ladders, portable steps, horses, etc.
9. Hand trucks, power trucks, wheelbarrows, buggies, etc.
10. Floors, platforms, stairs, railings.
11. Cranes, hoists, derricks, plant railways.
12. Lighting.
13. Electrical equipment, particularly extension cords.
14. Elevators.
15. Eye protection.
16. Other personal protective equipment.
17. Dusts, fumes, gases, vapors.
18. Pressure vessels—Insured? Inspected?
19. Any other explosion hazards as volatiles, gases, chemicals.
20. Other dangerous substances.
21. Oiling methods.
22. Inspection of chains, cables, slings and other lifting tackle.
23. Access to overhead equipment.
24. Exits.
25. Yards, roofs, and roadways.
26. Any other conditions suggested by the accident records.

Every one of these things should be considered in every inspection. All will not always apply, but none should be overlooked. The inspector of limited experience will be wise also if he develops pertinent detail under each basic item. For instance, under "Housekeeping" the subitems of chief importance would be:

1. Loose material and objects under foot.
2. Loose material and objects overhead.
3. Piling.
4. Projecting nails.
5. Disposal of scrap and waste.
6. Grease, water, or oil spillage.
7. Tool housekeeping.

8. Marked aisle lines.
9. Window cleanliness.
10. Painting.
11. General cleanliness.
12. Orderliness.
13. Fire hazards.

The initial interview. Since active executive interest in safety is vital to good safety performance, the inspector must appraise this somewhat intangible factor carefully. If interest is lacking in an important degree, his chief duty is to stimulate it, for, without it, even the most accurate of appraisals and soundest of recommendations will usually prove to be of little value. But a sound appraisal where findings are convincingly presented will often stimulate executive interest sufficiently to bring the needed executive action. Therefore, the first person to see, if at all possible, is the chief operating executive; next best, or even better, is to see with him the safety director or other person having primary responsibility for safety in the establishment as a whole.

Much will depend on the impression made by this first interview. A "sale is seldom made" during it; but if the executive does not see something of probable value in the presentation, the sale is probably lost. An amusing example will emphasize this point. A safety director whose talents ran more to high-pressure salesmanship than to safety engineering volunteered his services in calling on establishments to "carry the gospel of safety" to them. On his list was an establishment that (though he didn't know it) was a subsidiary of a firm well known for its excellent safety performance. He asked for and was granted an interview with the manager and presented a carefully worked out salestalk pointing out the seriousness of accidents and the fact that they are mostly preventable by the proper application of proved technique, described briefly the arrangement whereby his firm was donating a part of his services in the cause of safety, and ended up with a definite promise that a frequency rate of ten or better could be had without undue effort. The manager answered with the crushing comment that inasmuch as his frequency rate was already below five, he would be glad to act as consultant to the safety director.

Obviously, this safety director had nothing to offer this manager; but had he, before calling, or even at the start of his interview, found out what the safety status of the firm in question was, he could probably have secured its valuable coöperation in the safety program he was attempting to further.

The initial interview should cover at least the following:

1. Explaining the purpose of the visit. (If calling at the request of the executive in question, get a clear statement as to what is wanted.)

2. Find out what the accident record is like. (If the executive does not have it in terms of injury rates, costs, or causes, a brief statement of the advantages of doing so should be made; and if possible, the accident file should be secured and the reports run over with him. The frequency rate should be calculated and a comparison made with good practice. Key accidents should be selected for further investigation.)

3. Settle upon a definite plan for the inspection, covering particularly:

a. Who is to accompany the inspector.

b. Personnel to be contacted.

c. Route to be taken.

d. Type of inspection, as, general or detailed, or the inspection of specific equipment or processes or operations or combinations of such factors.

e. Probable time required (or allotted).

4. Arrange for a conference to discuss findings. If possible, decision should be secured as to who should be included, as this may influence the presentation considerably. Also, conditions found might make desirable a conference with the executive alone in advance of one including staff members.

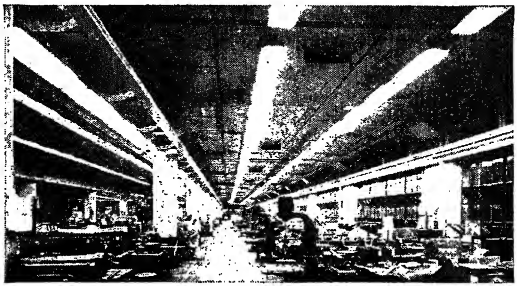
Working out the above points and others that might be pertinent should give the inspector at least a fair understanding of the executive's interest in and grasp of accident prevention. Much of the discussion can, without seeming to, be aimed at his education, provided he needs it. This is particularly true of the analysis of the accident record. If the executive's interest is aroused, he will wish to accompany the inspector on at least a part of the tour of inspection. Unwillingness to do so is evidence that the conference has not been very effective and greatly increases the importance of a convincing presentation of the inspection findings.

The inspection trip. If the establishment is of considerable size, a quick trip through it is usually advisable in advance of a detailed inspection. This is particularly true if the executive goes along, in which case readily noticeable substandard conditions and tell-tale indications of such factors as inadequate maintenance, supervision, inspection, training, and the like may be pointed out. Also, the accidents selected for investigation may

be looked into. Good conditions should receive favorable comment, but such commendation should not be overdone.

This "walk-around" will aid decision as to the order of the inspection. In well-planned, orderly plants, particularly those devoted to straight-line production, it is best to follow the process. In the multi-storied building, it is usually best to start with the roof and work downward.

The inspector should always remember that plant executives do not wish to be instructed on how to operate their business, but, nevertheless, that the alert executive is constantly seeking information and ideas that may be helpful to him. He can ill afford, however, to waste time on unsound ideas or inapplicable theory.



Courtesy of General Electric Co.

The inspector should have a bird's-eye view of layout and equipment before proceeding with inspection.

He is keenly on watch for indications by which he may judge the soundness of the advice he is given, and of course the competency of the giver. Not only, therefore, should the inspector always be tactful, but his attitude should be that of presenting his ideas and pertinent information in such form that the recipient may add them to his own initimate knowledge of his own business and thereby improve his performance.

For instance, it is usually much better to ask, "Don't you think a guard would be advisable for this machine?" than merely to announce, "This machine should be guarded." If the executive answers "No" to the first question and the inspector is unable to present convincing evidence that it should be guarded, the situation is no worse than before because belief in the need for guarding is essential both to satisfactory guarding and to faithful use of the safeguards themselves.

Recommendations must be practical. A suggestion that looks "silly" to the man "on the firing line" is worse than none, but the idea involved may be accepted and prove helpful if presented in a

form that indicates a different method of approach or a different viewpoint. One executive emphasized this point by remarking that a consultant whose services he valued "holds a looking glass up to me so that I can see myself go by."

It is a mistake to rush an inspection. If time does not permit a complete job, it is better to do part of it thoroughly than to cover the whole plant sketchily. The guide should not be permitted to hurry the inspection. If the initial interview has been effective, the guide will be anxious to show the inspector everything and get his ideas, an attitude that will aid the inspector greatly.

Since the foremen are the key men in safety, it is important to meet each foreman when starting the inspection in his department. The foreman should receive as careful consideration as the chief executive and will in general react similarly, the main differences being that the foreman deals chiefly with daily detail and the individual supervision and training of his men. He wants facts and practically usable ideas, not theory and not guesses. Each accident selected for investigation should be discussed in adequate detail with the foreman, particularly to discover the corrective measures applied to prevent a recurrence. The care with which a foreman investigates the accidents in his department is of fundamental importance, but the application of corrective measures is of even more importance.

The inspector should make descriptive notes of each department, giving the kind of work done or nature of the process, the department and building number or name, floor number, name of the foreman, and any other information necessary for accurate description and reference. All recommendations and comments on each department should be written down before leaving the department and each should be definite in wording and accurate in description; for example, a machine should be correctly designated by name and number (or whatever other designation is used in the department).

In summary, a successful inspection tour presupposes at least that:

1. The inspector has made a satisfactory impression on the executive in charge.
2. The purpose of the inspection is clearly understood by both the executive and the inspector.
3. The executive is favorably inclined to the inspection.
4. The inspector is competent to cover the ground in question.
5. He has secured, at least in reasonable measure, certain essential information, particularly the kind of manufacture or

nature of the operation, the company policy toward safety, the attitude of the chief executive, the accident record, the nature of the hazards involved, and the scope of the safety program.

6. As definite a plan of inspection as conditions permit.

The conference on the findings. The presentation of the conclusions reached from the inspection is usually as important as the conclusions themselves; for unless effective corrective action results, the time and effort has been wasted. Therefore, when the inspection is completed, the inspector should take sufficient time to run over his notes carefully and organize his presentation. He must decide what to include, what to generalize on, what to emphasize, what illustrative detail to use, and what recommendations to make, if any. Usually, it is a mistake to present a program based solely on his findings, because some, at least, of his conclusions may have to be modified in the light of information and viewpoints brought out in the conference. He should, however, have a tentative program for presentation if found desirable, but it is usually better to have the corrective program worked out in the conference from the discussion that will develop around his findings. In the first place, a jointly arrived at program is likely to be more practically workable than even the most experienced inspector-consultant could develop himself.

In the second place, those present at the conference will presumably have to carry out whatever program is undertaken. It is human nature to exert oneself more to carry out a project one has had a part in developing than something merely "handed down" with the order to "carry on."

The inspection report. The conclusions reached in the conference should be summarized at its close so that everyone present will know what has been agreed on. Also, each one should know just what is expected of him. It is usually best to have a stenographer present to record the decisions reached and prepare a copy for each participant. In most cases, however, the chief executive will prefer to have the inspector-consultant prepare a report based upon his findings, as modified by the conference and the decisions reached by the executive, and transmit the desired number of copies to the executive. This is the course normally followed when professional consultants are used. It has the great advantage of allowing the consultant to incorporate whatever detailed information and recommendations he believes will be useful. In a report to be studied at leisure, much more can be included than is possible in even the most extended conference.

The preparation of such a report requires much skill and careful work. Every statement should be clear and definite. The report should be primarily factual. Opinions when given should include, as far as practicable, the basis on which they rest, so that their soundness can be intelligently evaluated. Every report of any length should contain a summary, so that from it the reader can readily grasp the substance of the whole report. A report that is difficult to weigh rarely receives much attention. Finally, the needs and viewpoints of those for whose use it is intended should be a governing consideration throughout.

Inspection as a continuing plant activity

Inspection as a check on quality of product is a production essential; inspection to discover conditions that, if uncorrected, may lead to accidents and injuries is similarly essential to first-rate safety performance. Production inspection and testing procedure has been extensively written about and largely standardized; safety inspection has not, except in certain important but specialized fields, such as steam boilers and passenger elevators.

The student wishing detailed information covering specific equipment should consult pertinent technical literature, and in particular that dealing with the insurance of such equipment, for of necessity the insurance underwriters have taken a major part in the development of standards and standard procedures designed to control the hazards of the equipment they insure.

Much of the preceding discussion of the one-call type of inspection is applicable to the continued inspection work of an establishment. In fact, quite frequently the safety engineer or other staff member may be called on or may find it advisable to make such an inspection of his establishment or of another plant of his firm. In such case, he will have the obvious advantage over the outsider that his more intimate knowledge of his own firm and its operations gives, but he will, to some extent at least, lack the outsider's fresh unbiased viewpoint and varied experience. Also, the outsider usually has considerable prestige. This latter factor accounts for the experience plant engineers commonly have of being unable to secure management action to correct some condition that is promptly corrected upon the recommendation of an outsider. It is, therefore, often advisable for the plant engineer to make sure that the visiting consultant or inspector does not fail to discover such conditions.

A typical form of reporting on one-call inspection or reinspection by the plant safety engineer follows:

INSPECTION: Made by John Jones in company with Henry Smith on January 15, 1943.

Purpose: General observation.

Report forwarded to John White, Manager and Henry Brown, Safety Engineer.

General Conditions:

Housekeeping: Fair. Some sections require attention.
Layout of plant: Satisfactory.
Equipment: Generally in good condition.
Hand tools: Fair. Require periodic checking. Some now need replacing.
Lighting: Good, except as otherwise noted below.
Ventilation: Good except in paint-spraying area, building No. 1, 4th floor.
Floors: Good.
Electrical equipment: Recommend special attention be given motors in milling machine section. Otherwise generally fair.

Machine guards: Design satisfactory. Recommend additional guards as shown below.

Attitude of employees toward safety: Excellent so far as could be ascertained on a single visit such as this.

Building No. 10—Recommendations:

Building No. 10, 4th floor, Bay #401: Recommend change of layout of drill press area, in order to avoid crowding.
Bay #406: Flywheel on punch press. It is about four feet above the floor. It should be enclosed in a metal guard.
Bay #410: Milling machine control switches are at various locations on the machines. It is recommended that the locations be standardized at a point conveniently within the operator's reach. In many cases at present it is necessary for him to reach to the back of the machine to start or stop it.
Bay #413: Tool grinders in this area require attention. Tool rests in some instances were ½″ from the wheel, the glass shields were dirty and the men would, therefore, not use them. This could be improved by placing a light under the shield so that the men could see their work better. Hanging goggles on a machine for general use by all men is definitely advised against. Each man who should wear goggles should be provided with a personal pair carefully fitted to his needs. A test of grinder No. 607 showed that it was operating at 4000 r.p.m.; it was equipped with a ten-inch wheel for which the maximum safe speed is 2500 r.p.m. Mr. Smith asked the foreman to correct this condition without delay.

Usually when plant safety inspection is inaugurated in a given establishment, its purpose is chiefly that of bringing previously unnoted or unevaluated hazards to light. However, as these are corrected, its second and major function, that of discovering promptly hazards that develop from day-by-day operations, becomes relatively more important.

The fundamentals necessary to an adequate inspection service may be set down as:

1. Definite schedule as to what to inspect and how frequently.
2. Competent inspection personnel.

3. Adequate systematic procedure.
4. Effective supervision.

The inspection schedule. Literally everything in the plant should be inspected at some time (or times) by someone. The problem, therefore, becomes one of deciding what to include in the systematic safety inspection. The inspection necessary in the interests of production will cover much of the safety field. The safety inspection is additional and in theory at least should be added only where the inspection incidental to production is not adequate for safety. Often the first step should be to strengthen and broaden the scope of the production inspection. With that step functioning as fully in the interest of safety as is practicable, whatever else is needed may readily be added.

For example, the maintenance of an electric overhead traveling crane is essential to production so that the inspection service needed to keep it operating properly is a production essential. However, the safety engineer (or other person having major responsibility for safety) should scrutinize the inspection procedure to make sure that the safety of those who operate the crane or work with it is being and will continue to be adequately covered. Examples of the type of equipment that the production inspection setup will, if left to itself, ordinarily deal with inadequately or overlook entirely would be personal protective equipment, machine guards, housekeeping facilities and hand tools.

In the light of the above, the safety man will survey the entire establishment in detail, find out just what is covered by inspection and to what extent, and reach (or secure from the proper authority) a decision as to the extent to which the existing inspection procedure should be extended in the interest of safety. With this done, it is a comparatively simple matter to draw up a schedule for the additional inspection services needed. The schedule on page 90 showing the dates on which inspections are to be made is typical. The safety director receives a copy of each inspection report and checks each off on this inspection calendar as it is received. The schedule thus serves as a check on the up-to-dateness of the inspection work.

The dates selected for the inspection and the frequency of inspection are contingent upon the type and use of the equipment. For example, equipment used 24 hours per day will obviously require more frequent inspection than if it were used only 8 hours daily. Sometimes this fact is overlooked when a shift is added. Also, equipment whose faultless functioning must be relied on for safety requires the more frequent and painstaking inspection.

SPECIAL CALENDAR FOR INSPECTIONS

	Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*
Cranes	1	1	1	1	1	1	1	1	1	1	1	1
Hoists	2	2	2	2	2	2	2	2	2	2	2	2
Presses	15	—	—	15	—	—	15	—	—	15	—	—
Ladders and Scaffolding	5	5	5	5	5	5	5	5	5	5	5	5
Power Trucks	8	8	8	8	8	8	8	8	8	8	8	8
Auto Trucks	10	10	10	10	10	10	10	10	10	10	10	10
Small Tools	15	15	15	15	15	15	15	15	15	15	15	15
Portable Electrical Equipment	15	15	15	15	15	15	15	15	15	15	15	15
Goggles	10	10	10	10	10	10	10	10	10	10	10	10
Elevators	15	15	15	15	15	15	15	15	15	15	15	15
Grinders	5	5	5	5	5	5	5	5	5	5	5	5
Air Operated Tools	15	15	15	15	15	15	15	15	15	15	15	15
Slings and Chains	10	10	10	10	10	10	10	10	10	10	10	10
Pressure Tanks	—	—	15	—	—	—	—	—	15	—	—	—
Fire Equipment	20	20	20	20	20	20	20	20	20	20	20	20
Wash Rooms	20	20	20	20	20	20	20	20	20	20	20	20
Exhausts	25	25	25	25	25	25	25	25	25	25	25	25
Acid Storage	5	5	5	5	5	5	5	5	5	5	5	5
Dust Counts	10	10	10	10	10	10	10	10	10	10	10	10
Fumes	10	10	10	10	10	10	10	10	10	10	10	10
Railroads	20	20	20	20	20	20	20	20	20	20	20	20
Protective Equipment and Clothing	20	20	20	20	20	20	20	20	20	20	20	20

Examples are: elevator cables, the pull-out type of punch press guard, or respiratory protective equipment for use in a possibly lethal atmosphere. It is not practicable to make up a standard calendar for general use because industrial plants and the operations in them vary too greatly to permit standardization to that extent.

The inspection personnel. It should be obvious to all that any service on whose continuously effective functioning worker safety depends should be continuously maintained at a high level of effectiveness. Only personnel temperamentally suited to this type of work should be selected. They should be carefully instructed, trained, and supervised. Their interest in and realization of the importance of their work should be kept at a high level. The mere faithful following of prescribed procedure is not enough. Daniel Willard of the Baltimore and Ohio Railroad reported the following illustrative example:

A train he was on stopped at a division point. He got off to look things over. He noticed the thoroughgoing way in which a workman walked along beside each car and hit each wheel a lusty blow with a hammer. He stopped the man and complimented

him, and by way of making conversation asked him why he did it. The answer that came back was, "Dom'd if I know, sor."

Specialists are needed for much specialized equipment. Steam generators, elevators, and complicated electrical equipment fall in this class. Insurance underwriters maintain inspection services for their assured, which in general can be depended upon to have a good degree of competence. Also, there are inspection services that may be had on a fee basis. Many manufacturers of specialized equipment furnish such services. Finally, the state inspection services already discussed briefly in Chapter II should not be overlooked.

It will be necessary to make some close decisions as to just when to use the specialist and when to undertake to train selected personnel for the inspection. No general rule can be laid down. The internal inspection of a steam boiler, for instance, is obviously a job for the specialist; but a good mechanic can, with the help of the manufacturer's instructions, quite readily master the inspection and maintenance procedures necessary for electric traveling cranes. The cables used on the crane are, however, quite highly specialized equipment; and the manufacturer's full advice and instructions as to their safe use and maintenance should be meticulously followed.

Every foreman must of necessity maintain a more or less continuous inspection of the equipment and activities under his charge. He should develop a systematic procedure and follow it consistently. The coöperation between the foremen and the safety-inspection setup should obviously be close; for if it is not, there is likely to be friction, or duplication of effort, or inadequate inspection, or any combination of these three faults. An important part of a foreman's duty is to see that men under his charge operating hazardous equipment not only know what inspection they should include as a part of their operating practice, but also that they accurately and faithfully perform it. This is of particular importance with new men.

Some plants report very satisfactory results from appointing a committee of three to five employees from each department to make an inspection of the department. A new committee or a new member is appointed each month, thus, in time, giving every employee in the department a part in the inspection work. Appointments are made by the foreman who explains fully what is expected of the committee and emphasizes the need of frankness. Reports are made in writing to the foreman. Prompt and definite action on all recommendations is necessary, or the men soon lose interest. Each recommendation should be carried out with

reasonable promptness, or satisfactory reasons why it is not should be given.

Inspection by safety-committee members singly or as committees is chiefly valuable in bringing in additional viewpoints, in bringing additional experience and knowledge to bear, and in checking the inspection work done by others. Safety-committees are also particularly valuable in checking up on such operational matters as housekeeping, the handling of materials, operating methods, and work practices, and the use of safety equipment and personal protective equipment.

There is a definite need for adequately trained inspectors possessing the requisite basic knowledge. This is particularly true of unsafe practices and methods of operation. It is a simple matter to teach men how to inspect for the ordinary physical defects of plant and equipment, but detecting unsafe practices requires a good knowledge of the operation involved and particularly of the correct way of performing it. For example, take the drill press—a comparatively simple machine very widely used. The inspector should be so trained and experienced that he can note its hazards at a glance covering at least the following points:

1. Is the table stop bar in place and so used that the work cannot spin if it catches in the drill?

2. Is the hair of the operator close to the unguarded spindle so that it may catch? (Unless the fact is recognized that static electricity attracts the hair, a female worker, even with net hair protection, may be partially scalped.)

3. Is the drill properly sharpened for the job on which it is used? (A drill sharpened for steel should not be used on copper or brass, and vice versa.)

4. On a reaming operation, is the work properly fastened to the table, so that it will not ride up on the drill and strike the operator?

5. Are proper jigs and fixtures used to hold the work?

6. Is the operator holding the small piece in his hand and pushing up against the drill instead of placing the piece on the table and pulling the spindle down onto the work?

7. Are long chips forming which should be broken up by a chip breaker before they catch the hand?

8. Pieces piled on the table may be shaken off by the vibration of the machine and drop on the feet of the operator.

9. Does the operator reach behind the drill in order to get his coolant or wrench?

10. Is the operator wearing rings, a tie, a loose shirt, hair unguarded, bandages on fingers, gloves, long sleeves, or long sleeves on sweater rolled up and bunched above the elbow?

11. Is the stop and start button conveniently located, so that the machine can be stopped in an emergency without loss of time?

12. Is the operator in a comfortable position with the proper stool, if one can be used?

13. Is the table too high or too low for the operator?

14. Are his surroundings congested so that he has difficulty in getting the material to the drill and away from the drill?

15. Does he use his hands instead of a brush to remove the chips from the table?

16. Is the condition around the drill slippery, due to splashing of oil and other coolants?

17. Does he wear goggles? If not, should he?

18. Is illumination satisfactory?

The following points would be pertinent to the operation of the ordinary milling machine:

1. Is the pressure on the nut on the arbor satisfactory, so that when the arbor is under strain it will not break off and fly?

2. Is the work secure on the table?

3. What is the condition of the mallet used for tightening the vice? Is the raw hide chipping off so that a piece of it might strike the eye or so that it might glance off the work?

4. If a lead mallet is used, is it in good condition?

5. Are the springs still in the handles used for adjusting the table, or will they be spun around because of the possibility of engaging, due to the absence of the spring?

6. Can a guard be placed over the cutter and is it properly placed for the operation being performed?

7. Does the operator allow the table to move back far enough from the cutter so that the new piece may be inserted without his being cut?

8. Is he wearing goggles? If not, should he be?

9. If chips are flying, has he placed a guard of some kind to confine them within his own area?

10. Is his platform slippery?

11. Does he apply the wrench on the arbor and start the machine to run the nut up?

12. Does he remove chips by hand or with air instead of with a brush?

13. Does he work too close to the revolving cutter?

CHECK SHEET FOR USE OF PUNCH PRESS INSPECTORS

Plant Cat. No. .... Location (Dept.) ....

Type of Press ....

Foundation:

1. Is press securely bolted down?.....
   (a) To concrete?.................
   (b) Is there a shock absorber such as a wood gasket?..............
   (c) Or wood stringers?...........
   (d) Do all floor bolts seem solid?..

   ....
2. Working space:
   (a) Is there clearance between presses so operator will not interfere with neighbor?............
   (b) Ample room for:
      1. Cleaning machine?..........
      2. Handling material?.........
      3. Removing scrap?...........
   (c) Is aisle adequate for free movement of laborer to remove and replenish materials during press operation?...................
   (d) Is aisle space clear of material?

   ....
3. Lighting:
   (a) Is press so located that natural light is adequate on die?.......
   (b) Ditto for artificial light?.......
4. Means of disconnecting power:
   (a) Is push button properly located?

   ....
   (b) Is it foot or hand operated?....
   (c) Can it be accidentally operated?

   ....
5. Are the following properly guarded: Belts?....Pulleys?....Gears?...... Shafts?....Trip levers?.......Foot pedals?........................
6. Are operator's hands required to be between dies at any time?.........
7. Is press arranged for
   (a) Automatic feed:..............
      1. Are gears for it enclosed?....
      2. Are rolls guarded?..........
      3. If fed from side, is ram guarded?.................
   (b) Hand feed:
      1. Is it arranged to disengage trip mechanism at each stroke?...................
      2. Is it arranged to repeat until stopped?.................

Check

Bolts (flat threads)..................
Nuts ("   ")..................
Bolster—plates & holes..............
Wrenches (fit & condition)...........
Clutch—noisy—stick?...............
Brake—(adjustment)?...............
(heat)?.....................
Lubrication—Bearings leak?..........
Are they dry?..........
Are they worn?.........

General conditions:

Is floor clean?.....................
Is floor oily?.......................
Is operator adapted to work?.......
(a) Too tall?....................
(b) Too short?...................
(c) Wear corrective glasses?........
(d) Safety goggles?................
   1. Should he?.................
(e) Does he wear gloves?...........
(f) Is there adequate work space?..

   ....
(g) Is there adequate natural light?

   ....
(h) Is there adequate artificial light?

   ....
(i) Does operator set his own dies?

   ....
(j) Is bolster stripper spring properly blocked?......................
(k) Is operator wearing safety shoes?

   ....
   1. Do you recommend them on this job?..................
(l) Give drg. No. of job being run at this inspection..............
(m) Quantity on this order..........
(n) Date of this inspection.........
(o) Name of inspector.............

   ....

Do you consider this machine and general set-up of job to be safe?

....
(a) Is ram enclosed?...............
   (all sides)
(b) Are tweezers, pliers, pickers, etc. used?........................

Remarks

14. Is the cutting oil rancid?
15. Are his small tools in good condition?
16. Is he taking too big a cut so that the machine groans?
17. Is his feed too fast for the kind of work being done?

Systematic procedure. Although this starts with the schedule, that is not sufficient. The inspection procedure should be worked out in sufficient detail to make sure that everything of any importance is properly covered. Lack of order in the procedure inevitably results in overlooking some things. Lack of thoroughness leaves hidden defects. Again no set schedule of details can be given. The principle that should always be applied, however, is to list carefully all the safety defects that a given piece of equipment might develop and work out a practical inspection procedure to check for all of these.

WEEKLY INSPECTION REPORT OF TRUCKS

1. TRUCKS:

Condition of:

Steering Mechanism	Brakes ....
Directional Lights	Trailer Brake Mechanism ....
Head and Tail Lights	Horn ....
Marker Lights	Flashlight ....
Rear View Mirror	First-aid Kits ....
Flags available for projecting material (number)	
Fire Extinguishers	Blanket Roll & Hot Pads ....
Towing Cable (or Bar)	Truck Tools ....
Winch and Cable	Jack ....
Extra Head and Tail Light Globes	Chains ....
Preliminary Accident Report	Wind Shield Wiper & Defrosters ....
Spare Tire	Truck Flares ....
Is all unnecessary material removed?	Fuses & Containers ....
Remarks	Fuse Kit ....
Miscellaneous	

For illustrative purposes, forms used by one well-known firm are given. Note that the "Check Sheet for Use of Punch Press Inspectors" is in considerable detail and includes many points having to do with the practices of the press operator. Note that in both this form and the "Weekly Inspection Report of Trucks" the instruction and training of the inspector would have to include quite detailed standards as to just what is satisfactory for which job-safety analysis is practically a necessity. Note also that the foreman's report is much more general and goes to the foreman's superior.

MONTHLY SAFETY INSPECTION FOREMAN MEMORANDA

Date . . . . 19. . .

Our objective is—*To "see" and "correct" before the Accident occurs—by an inspection of YOUR department by YOU.*

You are expected to spend at least one hour each month, and return your report by the fifteenth, to Mr. . . . .

The following items are suggested for consideration. Look over the list before you start as a reminder. *There are many not listed.*

HOUSEKEEPING: AISLES . . . . . . PILING . . . . . . FLOORS . . . . . . RACKS . . . . . . RUBBISH . . . . . .

ALL TOOLS: CONDITION . . . . USE . . . . KIND . . . . METHODS . . . . . . GUARDS . . . . . .

PERSONAL PROTECTION: GOGGLES . . . . RESPIRATORS . . . . GLOVES . . . . . . CLOTHING . . . . . .

MISCELLANEOUS: LADDERS . . . . . . SLINGS . . . . . . TRUCKS . . . . . . LIFTING AND HANDLING . . . . . . EYEBOLTS . . . . . . FIRE HAZARDS . . . . . . DUST AND FUMES . . . . . . HEALTH . . . . . . RECENT ACCIDENTS . . . . . . YOUR DEPT. PROBLEMS . . . . . . INDIVIDUAL HAZARDS . . . . . .

REPORT:

The following items were noted and disposed of as indicated. Orders were marked "Safety."

1.

Signed: . . . . Department . . . . Building . . . .

Inspection made (Date) . . . . 19. . . Time (hours) . . . .

(Use added sheets as necessary)

Effective supervision. There is no exception to the general rule that if any activity is to be kept up to a high level of performance, it must be properly supervised. A considerable amount of detail must be established and there must be sufficient routinization to insure reasonably thorough performance. However, routinization tends to beget unimaginative routine performance that "merely goes through the motions." Supervision, therefore, must be continually alert to detect the signs of this and other lapses in the inspection work.

Corrective action. It should not be necessary to point out that unless prompt and reasonably thorough corrective action follow the inspection findings, the effort, time, and cost expended on inspection is wasted. Yet this situation is all too common and, where it exists, it points directly at the management. It is the almost inevitable result of executive failure.

The adequately safety-minded executive not only knows that effective inspection is necessary, but he also knows that orderly provision must be made for whatever corrective action the inspection shows the need of. Further, he knows that this activity, as every other function under his charge, must continue to receive its needed share of his supervision if it is to be kept up to the mark.

The procedure the safety-minded executive will set up will depend upon his managerial methods. It is his obvious responsibility after receiving recommendations for corrective action to discuss them with the staff members involved and make specific assignment for the action decided upon. The safety man should see that the various inspection reports are so presented or summarized or both as to conserve the executive's time and facilitate his action. Each report should be kept active until every item on it has received consideration and proper disposal. Some safety men have an individual form filled in for each hazard found. It is placed in a tickler file and kept "live" until the work has been completed. A sample follows.

SAFETY HAZARD TO BE CORRECTED

DEPARTMENT:

LOCATION: Building No. 10, Bay #401.

DATE: January 15, 1943.

MACHINE: Drill Press No. 600.

HAZARD: Stop and start electrical contact buttons, located in back of machine.

CORRECTION NECESSARY: Transfer these contacts from rear of machine to location at ridge of table directly in front of operator.
(*Note:* For location, see assembly of machine next to drill press in question.)

WORK TO BE DONE BY: Order issued on Maintenance Department.

WORK COMPLETED: Satisfactorily—January 21, 1943.

Equipment to be used by an inspector. The manner in which the inspector should be dressed and the equipment he may need is governed entirely by the kind of inspection he makes and the conditions surrounding his work. Each inspector should be properly equipped for the job he has to do, and he must remember

that he establishes a standard which others follow. His equipment may include:

1. Safe, snug-fitting clothing (avoid loose sleeves, flowing ties, and rings).
2. Safety shoes.
3. Proper goggles.
4. Hard hat.
5. Respiratory protective equipment (contingent upon the nature of the work and hazards involved).
6. Insulated flashlight.
7. Danger tags to attach to equipment that should not be used.
8. Padlock for locking out switches when inspecting certain machines or cranes.
9. Measuring tape.
10. Revolution counter for checking speeds of grinding wheels, pulleys, shafting, fly wheels, and saws.
11. Stop watch.
12. Camera.
13. Notebook.
14. Portable instruments for testing the atmosphere for toxic, inflammable, or explosive substances.
15. Light meter.
16. Velometer for testing air movement.
17. Pressure gauges.

REVIEW

1. Why is it important to deal with the chief executive before making an inspection?

2. In what way will an idea of the plant layout and operations assist the inspector?

3. Name ten of the fundamental hazards to look for during an inspection.

4. Why is it important to check the attitude of employees and management when making an inspection?

5. Give a complete list of unsafe practices to look for in the operation of a drill press.

6. What are the advantages of a safety check-off list?

7. What qualifications should a good safety engineer have?

8. In making an inspection report, what are the fundamental principles to bear in mind?

9. Why is it necessary to have a safety inspector do the work instead of the foreman?

10. Make up an inspection schedule concentrating on at least eight different kinds of equipment.

11. What are the advantages or disadvantages of continuous inspections as compared with special inspections?

12. What personal and special equipment is required by a safety inspector in your plant?

13. Why is it necessary for the inspector to be familiar with the company's policies and rules?

14. What are the advantages or disadvantages of having employees do the inspecting in place of the regular safety inspector?

CHAPTER X

Accident Investigation

Every accident constitutes proof that adequate preventive action was not taken. The safety-minded management plans all its plant and operations to be as safe as possible, trains its workers in safe practices and seeks their sincere coöperation in preventing accidents, supervises them carefully, makes job-safety analyses to determine and establish safe job routines, and maintains plant inspection to discover otherwise undetected hazards. It is obvious, then, that the hazards that slip past all these preventive measures and cause accidents should be discoverable by accident investigation. And so they are, but certain fundamentals must be met adequately if maximum value is to be obtained from the time and expense involved. This discussion has been prepared to present these essentials with certain detail of general applicability; but it is not intended to be all inclusive.

The purpose of accident investigation is to discover the causative factors, the hazardous conditions and practices that brought the accident about, *so that the proper action may be taken to prevent a recurrence.* The need is for full information as to causes—all the correctible causes that led to the accident, not just the major cause. This point brings out the importance of eliminating the factor of fixing blame. If part of the purpose is to fix blame, or if workers think it is, vital information will often be withheld or the facts will be distorted. The use of even the milder term "fixing responsibility" is questionable, unless it is made very clear that the purpose is to find out whose performance should have been better and in what way in order that he may be helped to improve and not again contribute to an accident.

At times the temptation to punish particularly thoughtless or inconsiderate action is difficult to resist. Experience, however, seems clearly to be on the side of limiting disciplinary action of any kind to instances of action so objectionable that the fellow workmen themselves favor punishment. Many firms leave decision on such cases with the workmen.

Presumably the investigation of accidents became an established procedure to combat damage claims under common law or under employer liability acts. The fixing of blame or responsibility

was of major importance. Under workmen's compensation acts, the data needed is that which determines whether or not the injury comes under the act, and if so, what compensation the injured person is entitled to; but the fixing of blame need not and should not enter.

The information gained from accident investigation should be used wherever it may apply throughout the establishment. The corrective action following each investigation is not complete until the question, "Where else might this apply?" is asked and fully answered.

Many causes of accidents

There are many causes of accidents, one or more contributing to every case. The investigator should understand how to pick out these causes and decide where to place responsibility for correction. His purpose should be to strive for a complete picture of the case, "starting from scratch" and working through the details. One authority stated, "There is nothing so eloquent as a fact."

Every operation is subject to three responsibilities:

1. The worker.
2. The foreman.
3. The management.

Since the worker has but one responsibility, the other two require investigation also when endeavoring to learn the underlying causes of an accident.

A complete accident investigation report made by men who report their findings honestly, impartially, and frankly will not contain the term "carelessness" because the term has little meaning. Unless the reason *why* adequate care was not taken is brought out, the *how* of getting it can only be guessed at. The *why* is likely to lead deeply into such management functions as employee selection, training, instruction, and supervision. All possibly pertinent factors should be considered.

The solution of any problem demands fact finding.

Learning the where, why, when, how, and to whom accidents are happening means a great deal in learning how to avoid them.

Naturally, a knowledge of the principal causes revealed permits of well-directed preventive effort.

Who should investigate—give authority?

Among the persons who make an investigation, we should include the man responsible for safety and the foreman or other

leader. These men should have authority to go as far as may be necessary to get to the root of the trouble. They must be careful to state the facts exactly as they found them.

Conduct of investigation

The foreman should participate in the investigation of accidents to his men. He should, to whatever extent circumstances seem to him to warrant, carry his own investigation further. He, better than any other person, can watch the minor injuries and can go much further in investigating them than it is practical for the safety man or a committee to do.

Some firms develop trained investigators, specialists in safety investigation. The safety director should be highly competent in this respect; but he may find another, such as an inspector, or safety committee member, or a foreman, whose aptitude and interest give him superior ability. When such a person is found, his abilities should be made use of to the maximum.

A committee of the supervisory staff is commonly used to investigate the more serious cases. For this purpose, it works well if executive interest in safety is keen; but if done merely at the request of the safety man, it is not likely to be effective; such men dislike dropping whatever they may be doing to undertake something else promptly and thoroughly, unless the executive makes it very clear that he wants "just that."

Committees of workmen are particularly valuable in bringing to light hazardous conditions and practices not readily discoverable by persons not actually doing the work. In every shop, there are older experienced "heads" who know the setup and the work practices so well that they can often "put the pieces together" much more surely than even the most skilled investigator not similarly experienced in the specific operation involved.

How best to get the necessary information in each case cannot be stated in a definite manner, because of the great variety of causative factors, tangible and intangible, which develop as one probes deeper and deeper for the truth.

The first requisite is to start with an open mind. "Someone was injured; what part of him is involved; what was he doing at the time; where was he; who was with him; what did he say happened; what do the findings of the doctor or nurse indicate?" Immediately following an accident is the best time to get this information.

The procedure of making an investigation in order to obtain optimum results requires good judgment and ability to collect the facts, weigh the evidence, arrive at satisfactory conclusions, and select suitable remedies.

Familiarity with the plant equipment used in the various operations will assist in the recognition of hazards that may have been overlooked for some time in the operation. The foreman or supervisor who accompanies the safety man must coöperate, since consultation with him as to possible causes and remedies will help to explore the underlying difficulties. We must remember that, in general, physical hazards as well as unsafe acts play important parts in the great majority of accidents. It is not sufficient merely to recommend a guard and overlook an unsafe act, such as rendering the guard inoperative or placing the hands in the danger zone unnecessarily. It is equally insufficient to limit attention to the unsafe act if a better guard would reduce the likelihood of injury from the unsafe act.

Promptness is essential since conditions may be changed quickly and the details forgotten. Promptness also helps to impress upon the minds of the workers in the immediate vicinity that management attaches great importance to their safety.

Minor injuries and no-injury accidents

The question as to whether all minor injuries should be investigated has been a much discussed point. Theoretically, they should be; but there are serious practical difficulties. Undoubtedly, a serious injury is, in most instances, merely one of a long series of minor injuries or close calls, all of which are from the same cause or causes.

The close calls are not easy to detect; the first-aid cases are relatively easy. If a close watch is kept on them (and such of the close calls as can be discovered), forewarning will thereby be had of most of the serious injuries. However, the number of first-aid cases in the average plant of some size is large enough to keep a considerable force of investigators working full time if all were investigated in as great detail as the serious injuries should be. Heinrich arrived at the ratio (for all industry) of 1 lost-time injury to 29 first-aid cases to 300 noninjury-producing accidents (or potential injury occurrences). Other data indicate that Heinrich's ratio is probably conservative, but also show wide variations as among the various industries, different establishments within the same industry, and in comparing different occupations. Many factors are involved. A working force that fully understands the infection hazard reports minor injuries for treatment and shows a high ratio. Where reporting is poor or the first-aid treatment is substandard, a low ratio with many infections is commonly found. Point-of-operation machine operation gen-

erally shows a high ratio of severe injuries; hand tool work, a very low one. Bad tool maintenance and the unskilled use of tools yield many minor injuries. Bad methods used in the handling of small, sharp, or rough articles bring a similar result. Under such conditions, one often finds 50 or even 100 minor cases per lost-time injury.

People generally dislike to be investigated in any way. Workmen who will willingly submerge this dislike to coöperate in the investigation of a serious injury will not do so willingly for a "mere scratch." One large organization which undertook the detailed investigation and reporting of every minor injury found its infection rate rising because the workmen got tired of being investigated and let many minor injuries go untreated.

It would be difficult to overemphasize the importance of closely watching the minor injuries. In most cases, a serious injury is merely one of a long series of close calls. It may be the first of the series, or the hundredth, or any other. In any event, these minor injuries and the close calls constitute warnings of the serious injuries certain to lie ahead if adequate preventive action is not taken.

The safety man (and the foreman as well) should maintain close contact with the first-aid department. Doctors, nurses, and first-aid attendants are in an excellent position to judge which cases should be investigated, and with the close coöperation of the safety man and the foreman can detect most of the cases that justify detailed investigation. An obvious example would be a minor injury from a falling object of some size or from a fall from a ladder. On the other hand, a finger nick received by a man at bench work is to be expected occasionally; but much repetition calls for investigation into such factors as the arrangement of the work, the tool housekeeping, the condition of the tools, the aptitude of the worker or workers involved, and the training they have received.

At the time of the accident

When an accident occurs and someone is injured, the first concern should be for the injured individual. He should be placed in the proper hands for treatment. Usually, his condition is such that immediate interrogation should be avoided in order to give the doctor or first-aid man an opportunity to make him comfortable, treat for shock, and take care of the injury. It is a mistake to run the risk of upsetting the victim by pressing him with questions. It is much better to wait until he has had a

REPORT OF ACCIDENT TO AN EMPLOYEE

INJURED EMPLOYEE: Name .... Number .... Dept. ....
Address ....
Nationality .... Age ..... Married or Single? .....
Number of children under 18 years .... Number of dependent adults ......
Occupation when injured .... Was this his/her regular occupation? .....
If not, state regular occupation .... How long in department? .....
Piece or Day Work? .... Day rate ....

ACCIDENT: Date .... Hour .... Place where accident occurred
....
Full description of how accident happened. Also name, part, and shop number of machine or tool appliance concerned in accident ....
....
Was part of machine causing accident properly guarded at time of accident? ......
Hand or mechanical feed? .... Give description of guards ....
....
Was employee following Safety Rules? .... Was accident due to lack of ordinary care by injured person? .... If so, how? ....
....
Was accident due to negligence of any person other than the injured? ....
If so, who and how? ....
How can recurrence of such accident be prevented? ....
....

INJURY: Full description of injury and part of person injured ....
....
....
Did injured resume work after receiving medical attention, or was he/she sent home? ....
If sent home, what time did he/she ring out? .... Is employee back to work?
Name and addresses of witnesses to the accident ....
....

Name of foreman in charge of work

Name of immediate supervisor

Where possible, give further description of accident and its cause on the back of this report, illustrating, if possible, by sketch, drawing, or photograph.
Report made out by .... whose position in the Company is ....
Date report made out .... Signed ....

REVIEW OF EMPLOYEE ACCIDENT

Name...Pay No..........................Bldg...............

Age...............Service with Co...............Occupation.................................Date of injury...........................

Nature of injury...

Cause of injury...

....

Probable length of disability...

ANALYSIS OF CAUSE

INSTRUCTION	**UNSAFE PRACTICE**	**POOR HOUSEKEEPING**	**IMPROPER PLANNING**
( ) None	( ) Taking chances	( ) Improperly piled	( ) Layout of operation
( ) Not enforced	( ) Short cuts	( ) Congestion	( ) Layout of machine
( ) Incomplete	( ) Haste	( ) Material lying about	( ) Unsafe processes
( ) Erroneous	**PHYSICALLY UNFIT**	( ) Bad containers	( ) Type of tool
INABILITY OF EMPLOYEE	( ) Defective		( ) Lack of equipment
( ) Inexperienced	( ) Fatigued	**DEFECTIVE EQUIPMENT**	( ) Lack of data or rules
( ) Unskilled	( ) Weak	( ) Misc. material & equipment	
( ) Ignorant	( ) Sick	( ) Tools	**MENTALLY UNFIT**
( ) Poor judgment	**IMPROPER WORKING CONDITIONS**	( ) Machines	( ) Sluggish—fatigued
LACK OF CONCENTRATION	( ) Ventilation	( ) Lack of maintenance	( ) Violent temper
( ) Attention distracted	( ) Sanitation	( ) Poorly made	( ) Excitability
( ) Inattention	( ) Light	( ) Not apparent	( ) Sick
( ) Thoughtlessness	( ) Temperature		( ) Home troubles
POOR DISCIPLINE	**PHYSICAL HAZARDS**	**UNSAFE BLDG. CONDITIONS**	**IMPROPER DRESS**
( ) Disobedience of rules	( ) Ineffectively guarded	( ) Fire protection	( ) No goggles, gloves, masks
( ) Interference of others	( ) Unguarded	( ) Exits	( ) Unsuitable—long sleeves
( ) Fooling	( ) Guards removed	( ) Floors	( ) High heels—defective shoes
( ) Disregarded instructions	( ) Guards tampered with	( ) Openings	( ) Failure to wear safety shoes
		( ) Miscellaneous	

( ) Give cause if not covered by any of the above:

RESPONSIBILITY: Employee...............Supervision...............Divided, E and S...............Not placed.........................

Reason for placing responsibility as above..

....

....

What action by supervision might have prevented accident?..

....

....

....

What action will be taken to prevent recurrence?..

....

....

....

Date.................................. Made out by.. Signed by...
Foreman Supt.

Send 1 copy to Works Manager and 1 copy to Safety Dept.

chance to collect his thoughts and get his nerves under control. Usually, the investigator can go right to the scene and get a fairly complete story from those who were present and from the conditions he finds upon his arrival. In all serious cases and in all other cases where practicable, conditions at the accident scene should remain unaltered pending the investigation.

When the safety director directs or himself undertakes to investigate an accident, his approach to the foreman and to the injured man should be indicative of trying to help and not in any way of a desire to convict fault. This approach helps greatly to bring out the facts, for neither will feel it necessary to conceal anything.

At the scene of the accident, all the conditions should be reconstructed mentally, the occurrence pictured, reenacted if necessary, and only then should definite conclusions be reached. The very human tendency to reach a conclusion early in an investigation and then use only that subsequent information that tends to confirm it must be resisted. Doubtful points should be checked on from as many different angles and as objectively as possible.

The report form

Practice varies, but it is common procedure for the foreman to fill out a standard report form covering his findings. The results of any investigation additional to his are usually made up in descriptive form in such detail as circumstances warrant. The samples herewith of forms in use are fairly typical. Note that the one is merely a descriptive report of accident, a single question as to how to prevent a recurrence. The other is a "Review of Accident" form calling for a detailed analysis of the accident with the assignment of responsibility and also calling for definite preventive action. The safety man will make his own notes on each such case and in addition to his copy of the foreman's report and that of any other investigation will have the medical report. He is thus in a position to weigh all the evidence, investigate further if necessary, advise on and follow up on the corrective action, and see that any information gained that may have a bearing elsewhere is made full use of.

Examples of cases. The following examples of the fruits of accident investigation are illustrative.

Case 1—Carbon tetrachloride. Two men using carbon tetrachloride reported to the dispensary with headaches. The first one had placed a one-gallon can between an electric fan and himself and the fumes were being blown in his face.

The simple remedy of placing the can so that the fumes were blown away from him overcame the condition. In addition to this, the investigators found that 25 per cent of the quantity of carbon tetrachloride he had exposed was sufficient for his needs.

The other man was dipping some laminations in a small can of the fluid and spreading them on his bench to dry. He was inhaling the fumes while these were drying. A change in this procedure so that the dipping operation was done just before he went home overcame the trouble. Both of these jobs were done occasionally, involved only a small quantity of the cleaner, and did not require an exhaust; but they did call for an understanding of the nature of the material and the exercise of judgment in using it. These two cases pointed directly toward the need for more careful and adequate instruction and better supervision.

Case 2—Punch press steel lift truck. To assist punch press operators who handle large dies, a company used steel trucks to convey the dies to and from the machines. The height of the trucks is adjustable so that the dies may be pushed from the truck to the bolster plate without lifting.

A motor located near one of the presses prevented a man from placing the truck close enough to one of the machines. One day a die got away from the operator and dropped to the floor.

An ordinary extension for the truck eliminated the hazard and simplified the work of placing the dies on the press. This hazard might have been foreseen when the machines were installed; or if not, plant inspection should have caught it. So should job analysis. Finally, the foremen should have seen it. It obviously slipped through all these preventive activities.

Case 3—Battery truck struck drill press. One of the battery trucks bumped a small drill press lightly, but, nevertheless, knocked it over. No one was injured. Investigation revealed that the Maintenance Department had placed lag screws in the wooden floor blocks instead of placing them through the blocks and into the concrete below. A further check showed several machines lagged down this same way in error.

Case 4—Babbitt job. A company had a job on which babbitt was poured to fill a hole in a casting. A plate was placed under this hole to hold the babbitt in place. In order to prevent it from running out through the spaces between the casting and the plate, the operator's practice was to fill in these spaces with wet asbestos. When the molten metal touched the wet spots, a slight spattering would occur. Goggles and special sleeves were worn to prevent burns, but one day a man received face burns from the spatter. The remedy was simple, namely, to substitute whiting mixed with a very heavy oil. More adequate instruction should have prevented this unsafe practice. Job safety analysis should have caught it. So should the foreman and the workmen's safety committee.

Case 5—Small construction job. A concrete foundation for some additional equipment was being put in under the point where power lines (1100 v.) entered the building. A worker undertook to straighten out a reinforcing rod that projected above some concrete already placed by using a piece of pipe as a lever. The pipe touched the power line, and the workman was severely burned. The findings of the investigation were:

1. A safer location could have been selected for the additional equipment.

2. If this was not done, a protective shield should have been placed under the power wires.

3. This hazard should have been foreseen by the supervisor and careful instructions issued concerning it.

4. There should have been closer supervision.

Notifying other departments and plants

After the investigation of an accident has been completed and a method of prevention has been decided on, our next step is to find out what other departments or plants may have a similar condition which requires attention.

The information should be broadcast to foremen and all interested safety men in other plants, so that they may profit by the experience of others. This is usually done by a letter giving the particulars and a photograph or sketch if necessary.

This system is also used when a good guard is designed or a safer method of doing a job is found or some special new safety equipment is placed on the market. In this way men are kept abreast of the times and can take action promptly. Experience has shown that the value of information obtained is dependent on the use which is made of it.

Corrective action—Profit by experience

It must be understood that everything possible should be done in all plants to prevent accidents, because that is the first important step. Second, if an accident occurs, we must profit by it so that there will be no recurrence. The adage, "It's an ill wind that blows no good," applies to accident prevention.

Since the real purpose of an investigation presupposes action, it must be prompt; otherwise, it will be largely wasted. Action should include:

1. Prompt consideration of every recommendation and compliance with it.

2. If recommendations are not to be followed, an explanation of the reasons is required.

3. Delays necessary in order to make changes or obtain other equipment should be explained fully.

4. Consideration should be given in all other departments, to see if the same condition applies, whenever physical hazards or unsafe practices are found.

5. The effectiveness of an investigator is contingent upon the decisions, the distribution of knowledge pertaining thereto, and the action taken.

Summary

Reviewing this matter of investigation of accidents, we have these salient points:

1. Analyze the case carefully and impartially.
2. Have the proper people do this.
3. Don't dismiss it by saying the man was careless.
4. When you get the correct information, take some action to prevent a recurrence.
5. Do not fail to apply preventive measures in all sections where a similar hazard may exist.
6. Avoid looking for excuses and get the causes.
7. Avoid trying to convict someone for negligence, and remember that the worker, the supervisor, and the company are usually at fault to some degree.
8. A knowledge of all circumstances surrounding an accident is essential.
9. Make use of the information obtained.
10. A summation of all these points usually indicates a definite need for more education and training of the worker as well as a closer follow-up by supervisors and management.

REVIEW

1. Who should investigate accidents? Explain why.

2. When should a worker's committee be used in an investigation?

3. Why should investigation be made promptly?

4. What should investigators look for? (Name 5 important points.)

5. After the investigation is completed, what action should be taken?

6. Explain the difference between a direct and indirect cause-finding in an investigation.

7. *Problem.* Hole in floor, reported to Maintenance Department by foreman. Two days later man injures foot when he tripped in hole.

a. Give causes.
b. Explain action required.
c. Who should investigate?

8. What place has job analysis in accident investigation?

CHAPTER XI

Layout and Arrangement; Purchasing for Safety

LAYOUT AND ARRANGEMENT

The layout and arrangement of a plant or any industrial undertaking involving equipment is generally done by engineers with special training. That plant layout should include full provision for the safety of the worker as well as the production requirements is obvious. If the safety engineer has a fair knowledge of the principles the layout engineer applies in planning a plant and its operations, he will be greatly assisted in checking over the plans before actual work has begun, and thus the expense of later changes will be saved. Such knowledge will also help him in detecting hazards due to faulty planning of established plants.

The factors that influence plant layout

It is costly to have products that are being manufactured retrace their steps through the factory building. It is also costly to lift them to upper floors. In other words, holding the handling and transporting of materials to a minimum helps hold costs down. Since the handling of materials and articles is a major source of accidents, keeping handling to a minimum helps to keep accidents down. This is merely another example of the intimate relationship between accidents and costs and is particularly important because of that relationship.

The development of the plans for the modern factory building should include thorough considerations of all processes and operations involved, including the work that will be performed and the prevention of injury to the workmen performing it. Building the plant and then fitting the process to it inevitably involves compromises by which safety (and, as a rule, cost and efficiency as well) suffers. This might seem to be an argument against the use of the standardized type of factory building, but it is not; for with proper planning, the benefits of standardized construction can be had without compromises hurtful to safety.

The essentials that must be met in the planning will be influenced by such factors as the type of product to be made, the mate-

rials to be worked with, the kind of operation contemplated, and the type of personnel required. A product lending itself to continuous production, as paper or textiles, imposes one set of conditions. A product assembled from manufactured parts, as shoes or automobiles, brings other conditions. Certain specific properties that wood possesses determine the methods of its processing; metals require different methods. The manufacture of magnesium from sea water involves entirely different plant and process from its manufacture from the ore. Workmen having skills and aptitudes suited to the manufacture of fine watches would be extremely unlikely to "fit" in blast furnace operation. The tremendously important and rapidly developing and expanding field of chemical industry brings a wide variety of new problems and varied techniques.

In general, the importance of the kind of factory building and layout as a primary tool with which to carry on production, and into which all other production tools and mechanisms fit, cannot be overestimated. The building and layout must fit the job to be done, if that job is to be done most effectively.

The relationship between plant layout and process arrangement is so close that health and accident hazards cannot be disassociated from either of them. If the planner or layout man is thoroughly familiar with conditions and applies accident-prevention principles, he will not overlook provision for the following:

1. Adequate space. Congestion leads to confusion in the area and the probability of accidents. The absence of sufficient room for machine or equipment makes it more difficult to work; and, therefore, the planner must have in mind the size of the equipment and the necessary radius of action required by the worker as well as the area needed for storing work to be done, work completed, and the handling of this work by himself or others. Ample head and elbow room, particularly over and around moving equipment, such as traveling cranes and other apparatus requiring servicing, sometimes is overlooked. Good practice provides for clearance such that a person riding or working on the top of such equipment will not be in danger of getting caught against or striking his head against girders, ceiling, columns, and so on. Inadequate storage space is also responsible for poor housekeeping and increases the difficulties of handling and storing incoming materials, those in process, and the finished product.

2. Safe access. Failure to provide for safe access to every point to which men must go, such as cranes and on top of boilers and machines, is responsible for many falls. In order to realize fully the importance of such provision, the safety planner should

"follow the oiler or repair man" with sufficient frequency to keep well informed as to the hazards he faces in his daily work.

3. Safe maintenance. This includes particularly the safety of men doing such work as window cleaning and repairs, overhauling of overhead electrical equipment, and work on cranes, machinery in pits, and in tunnels and out-of-the-way places, such as elevator penthouses.

4. Adequate air and light. The number of employees who should work in a given number of cubic feet of space varies considerably and is contingent upon the nature of the work and the presence of air contamination. Many factors are involved in good lighting. The intensity of light required depends entirely on what the area is used for, since obviously a tool maker's area requires considerably more light than does a storage section. Glare, quality of light, location, location of light source, contrasts in color and brightness, flickering and shadows, all must be considered. The provisions of the "American Standard" should be complied with.[1]

5. Services. In the layout, provision is made for the arrangement of machinery and fixed equipment. Provision must also

Courtesy of General Electric Co.

Machines properly spaced; wide, clearly marked aisle; ample working space.

be made in the arrangement for servicing those areas so that traffic will flow in and out without interfering with the various operations. Modern factories provide room for battery trucks,

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[1] In 1915 the Illuminating Engineering Society issued its "Code of Lighting Factories, Mills, and Other Work Places." This was approved as American Standard and revised from time to time. The latest revision, "Recommended Practice of Industrial Lighting," published by the Illuminating Engineering Society, 51 Madison Avenue, New York City, was approved by American Standards Association in 1942 and issued as "American Recommended Practice of Industrial Lighting."

three- or four-wheeled push trucks, various skids, and tote boxes. The widths of aisles, in order to provide for traffic, are of prime importance. If battery or other powered shop trucks are used, the minimum width for two-way traffic requires an allowance of at least three extra feet, after making provision for the width of two trucks.

Pedestrian rush-hour traffic flow to time clocks, lunch rooms, and exit gates, makes it necessary to provide extra clearances in

Courtesy of General Electric Co.

Good lighting and aisle markings; good order.

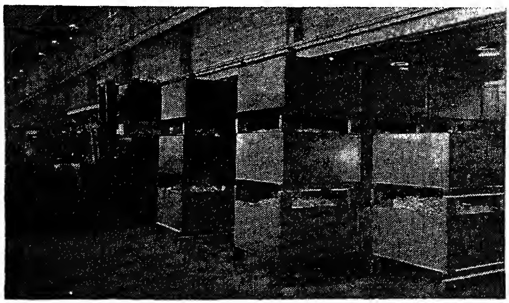
order to accommodate the peak loads. Allowances must also be made for handling bulky loads. Marking the aisles, generally with white or yellow paint, and eliminating blind traffic intersections, help considerably in keeping traffic lanes open, so as to provide for a steady flow.

6. Expansion. A far-sighted planner allows for expansion of business in the layout. If this is done properly, the need of rearranging departments or moving from one place to another in order to overcome congestion and expedite manufacture is avoided or at worst minimized.

Management may consider planning and processing from only a cost, quality, and volume standpoint, overlooking the fact that effective control of these will largely reduce accidents. Poor planning is often a major factor in a high accident rate, and the safety man can do much to correct it. The need for changes is indicated by unduly large amounts of materials in process in operating areas, workers interfering with one another, overcrowding of production areas, traffic jams, accumulation of waste and scrap, and processes not following one another in an orderly sequence. Recommendations by the safety man should be given careful thought, since changes involve a considerable expenditure

in many instances; and unless the problem, with the remedy, is properly presented, the probability of corrective measures being taken is lessened. A considerable knowledge of industrial management is necessary in order to appreciate the principles involved and to make practical recommendations for correction.

An important duty of the safety man should be that of checking plans and specifications for layout and arrangement of equipment. This is an important function because it affords an opportunity to discover and correct conditions that may otherwise be built into the plant and plant equipment and later result in injuries.



Courtesy of General Electric Co.

Conservation of space by high piling of specially designed containers.

The proper placing of machines, allowing sufficient aisle space and room for the material that will be placed around them, is of particular importance. The kind of flooring to be used, the safe floor load, the material with which to construct platforms, the placing of sheet metal guards, curtains, or other things to confine the process to a given area are also important. For instance, provision should be made for placing a shield or a curtain around a welding area or section so that the injurious rays do not cause flashes or other injury to those working or walking near by. It is poor practice to locate a chipping operation along an aisle or other space unless a proper shield is installed. Metal shears should be so located that the cut pieces will not drop off or fly into an aisle or other frequented place. A paint spray booth using a volatile solvent should never be located next to a welding area, because of the explosion, as well as the fume and fire, hazard. One does not want a furnace in close proximity to the carpenter shop with its wood dust hazard and its considerable stock of inflammable material.

Consideration should be given to the location of the tool cribs so that workers do not have to walk too far to get their tools. Generally, we find the cribs with windows opening onto an aisle. Allowance should be made for space such that a man can stand at the window to get his tools and not be endangered by or interfere with the aisle traffic, which, incidentally, may include loads borne by overhead cranes.

Drinking fountains should not be located near machines which throw off dust and dirt or where fumes from painting processes are created. Drinking fountains are usually installed to suit the convenience of the standard plumbing installation, and therefore the safety and convenience of the persons using the fountains is at times not adequately provided for. At times it is less expensive and may be better to relocate the process or equipment than to move the fountain.

Isolation of hazardous locations

Much too often we find paint-spraying, metal-cleaning processes and dusty work placed on the manufacturing floors without consideration for the health of and annoyance to workers in other sections. Whenever possible, the layout should include isolating by using a separate building or partitioning off the area of these operations. In order to protect the employees within the hazardous areas, allowance should be made for the installation of exhaust equipment with collectors. Sometimes it is sufficient to carry the exhaust well above the roofs. In each instance, the nature of the substance, the possibility of its being carried back into workrooms by natural air motion or creating a neighborhood nuisance, should receive full consideration.[2]

Provision for outlets and other electrical connections as well as for supplying compressed air for portable equipment is often overlooked. An adequate supply of connections would eliminate the need of running hose lines and electrical leads across aisles.

Marking bays so that locations of hazards can be easily identified is of great value. It is common practice to use first the building number, next the bay by using A, B, and C running crosswise of the building, then the floor number, and next the bay number counting lengthwise from one end of the building to the other. For example, "10-B, 403." This would indicate Building No. 10, B Bay, 4th floor, and allowing for the usual twenty-five feet, length and width, the third bay from the starting point, or seventy-five feet from the end.

[2] More detailed treatment of these factors will be found in Chapter XXXI.

FLOOR PLAN TO INDICATE
LOCATION BY BAY NUMBERS

10A404	10B404	10C404
10A403	10B403	10C403
10A402	10B402	10C402
10A401	10B401	10C401

10 = Building #10.
A-B-C = Location of bay from side to side.
4 = 4th Floor.
01-02-03-04 = Location of bay from end to end.

PURCHASING FOR SAFETY

The safety man in industry is not an entity unto himself. It is necessary for him to coöperate with the entire organization and also to obtain the coöperation of other departments and men in the organization. This high degree of teamwork is especially important as it relates to the purchasing of equipment and supplies. It is the purchasing agent's responsibility to buy various items of machinery, tools, equipment, and materials used in the establishment. His responsibility should also be to see that these are not only usable on the various jobs but also that they include the maximum of safety for the user. In some companies a safety man is charged with the responsibility of checking all plans and specifications for machinery and equipment. Certain items that are reordered from time to time, such as safety shoes, goggles, respirators, protective equipment, and the like, are included on standard lists which have been prepared after due investigation and approval; and the purchasing department is instructed to select from the types on these approved lists.

This is a much more satisfactory arrangement than to have the responsibility for safety equipment rest with the department head where the equipment is used, although he should be in close contact with the individuals who prepare the approved lists. These individuals ordinarily would include a representative of the engineering or methods departments where plans and specifications are prepared, as well as the safety and purchasing departments.

This same degree of coöperation should exist in the small plant as in the large. Those responsible for the protection of the workers

must see that safety is adequately provided for in the purchasing of supplies and equipment.

A short-sighted purchasing policy would place price above safety, but every fully safety-minded management knows that a policy of careful attention to safety in all purchasing is actually a money saver.

Purchase of machinery

As a result of the persistent demands of safety men and safety organizations, as well as the adoption of legal requirements that machinery be made safe, great progress has been made by machinery manufacturers in making their products safer to use. Safety is being built into machines more and more through safer design and construction and more complete guarding. However, there is much need for further improvement, particularly of widely used point-of-operation machines, standard models of which are offered in the competitive market. This applies particularly to woodworking and metalworking machines. The usual practice with these machines is to add guards designed and manufactured for attachment to the standard models rather than to design machine and guard together as a functioning whole. While fairly satisfactory guards for these machines are available, many points of hazard can be much more adequately safeguarded by including the full safety of the operator as a basic requirement in the design and construction of the machine.

Further improvement in present practice depends upon the extent to which purchasers will demand fully safeguarded machines. Purchasers who buy on a price basis often fail to take the safety of the operator into account. They "shop around" for the machine, and, if a guard is required, follow a similar practice in buying it. Safety suffers in the process, for such guards vary widely in their effectiveness; they are in fact after-thoughts, and they generally show it. Any machine part on whose correct function men's safety depends should be considered the most precious part of the machine, and its appearance should be indicative of such an attitude. Poorly designed, poorly finished guards obviously added as more or less of an after-thought testify eloquently against any professed desire for "safety first."

Purchasing unguarded machines to be guarded later is also not likely to save any money. Often the purchased guard must be altered or added to, or extra cost is involved in installing it; therefore the final cost of this course may be high.

The purchaser who is so little safety-minded that he purchases on this basis is not likely to be able to judge correctly the relative

merits of guards sold competitively or to appraise the sales arguments of the competing salesmen. As a result, guards are often purchased, tried, and discarded, and the machine is operated unguarded until an accident or a specific requirement as to guarding causes another type of guard to be tried and, perhaps, discarded in turn.

Purchase orders should in all cases specify that machinery be fully safeguarded and comply fully with state or other applicable safety requirements. Machinery manufacturers will coöperate gladly with purchasers to work out safety problems just as they commonly do all problems of operation; but the need of and desire for such service must be a part of the purchase inquiry if it is to be rendered effectively. Even this procedure does not, however, preclude the need of a safety inspection of new equipment before it is placed in operation, because not only may some things be overlooked in planning and building it, but the installation may be faulty. Then, too, operating plans may have changed by the time the machine has been received.

Protective equipment and supplies

The safety man who keeps himself posted on the new equipment and supplies available, together with their advantages as compared to others, is in a good position to decide what should be used in his establishment because he knows the demands of his organization and the application of the equipment, as well as the outside sources of supply.

All safety equipment and safety items should definitely come under the jurisdiction of the safety man. All those that are needed in a given plant should be included on a standardized list in order to guide the purchasing department in placing the orders. The following list is suggestive:

1. Acid-handling equipment.
2. Carboy-handling equipment.
3. Electrode holders.
4. Face, head, and eye protection (goggles, helmets, facemasks, hard hats, etc.).
5. Fire-fighting equipment.
6. Foot protection (safety shoes, foot protectors, boots, etc.).
7. Guards for specific purposes.
8. Hair protectors (hair nets, caps, turbans).
9. Hand protection (gloves, hand leathers, finger cots).
10. Ladder feet.
11. Linemen's equipment.

12. Protective clothing (aprons, sleeves, shoulder pads, asbestos garments, knee and shin pads, gauntlets, etc.).
13. Respiratory protective equipment (respirators, gas and hose masks, oxygen apparatus, sand-blast helmets).
14. Safety cans.
15. Safety literature, posters, bulletins, signs, etc.
16. Safety mats.
17. Special safety tools.
18. Stretchers.
19. Testing instruments (CO indicator, speed counter, explosometer, velometer, etc.).
20. Wire rope clamps.

Of course it is not sufficient merely to provide for the coöperation of the purchasing department and the safety engineer in the purchasing of supplies. The proper application of this equipment is of vital importance in order to secure the benefits expected. This application can be made through systematic procedure adequately followed up and maintained. It is essential that each foreman know fully what safety equipment should be used by the men under him, how it should be used, and its limitations. In some plants, foremen's meetings are held for instruction and discussion in this field; in others, it is handled chiefly by direct contact between the safety men and the various supervisors. Finally, close coöperation between the foremen and the safety man is needed to discover the limitations of the safety equipment and also to discover desirable improvements or additions.

Examples of the need of adequate information and correct application would be:

1. A respirator suitable for filtering out dust particles is of little or no value when used in an area containing fumes. An inadequate protective device may be worse than none, for it gives a false sense of security.
2. The hazards involved in emptying the acid out of carboys by hand might be met by substituting a pump; but if this applies too much pressure or suction and thus causes a breakout, one type of hazard has merely been substituted for another.
3. A gas mask suitable for an area in which carbon tetrachloride fumes are present would in most cases afford little or no protection against monoxide fumes.

REVIEW

1. Why is plant layout important from a safety point of view?
2. Name five basic principles considered in plant layout.

3. How can expense be reduced through proper planning?

4. What special consideration must be given in layout to provide for paint spraying? Chipping? Arc welding? Cleaning metal with chemicals? Sand blasting?

5. Why is it important for a safety man to have the coöperation of the purchasing agent?

6. Name ten articles in which a safety man's decision is important before purchasing.

7. What specifications would you include when ordering equipment such as a milling machine, lathe, tool grinder?

8. How does a safety man arrive at a decision as to what type or kind of protective equipment is to be ordered?

CHAPTER XII

Plant Housekeeping

In factory parlance we use the term housekeeping to signify not only cleanliness but a place for everything and everything in its place. A condition of this kind cannot be maintained by an occasional grand clean-up and setting things in order. It must be continuous and given proper attention and thought. A place is clean when it is free from unnecessary things. It is in order when those things that are about are in their proper places, properly arranged, and in satisfactory condition. Grease or oil out of place is a frequent cause of floor slipperiness. If articles fall from overhead, they have been out of place. If dirt and litter is about, these are out of place. If material is poorly piled or placed, the material is out of place.

An orderly arrangement is not only conducive to a good accident record, but it is representative of competent management, efficient workmanship, and a better place in which to work.

Typical accidents due to poor housekeeping

1. Tripping over loose objects on floors, stairs, and platforms.
2. Articles dropping from above.
3. Slipping on greasy, wet, or dirty floors.
4. Running against projecting, poorly piled, or misplaced material.
5. Tearing hands or other parts of the body on projecting nails, hooks, or sticks.

Typical items of unsafe housekeeping

1. Excessive material, waste, or chips in working area.
2. Aisles congested.
3. Tools left on machines.
4. Waste containers overloaded.
5. Locker and washrooms in disorder.
6. Acids in open containers.
7. Broken glass about.
8. Electric leads and air lines across aisle.

9. Poor lighting.
10. Insecure, uneven, or otherwise improper methods.

The following lists are purposely limited. The student of the subject may find it mentally stimulating to develop his own lists, making them as complete as possible.

Housekeeping assistants

Since arrangements that are advantageous to production are also advantageous to housekeeping, consideration must be given to, and provision made for, the following:

1. Planning and layout of plant.
2. Proper layout of work area.
3. Anticipation of waste, scrap, dust, spillage, liquid splashing, and so on, and inclusion of means of control such as:
   a. Receptacles for waste and scrap with orderly means of disposal.
   b. Over-flow pans.
   c. Scrap guards.
   d. Chip screens.
   e. Chip catchers.
   f. Chutes.
   g. Exhaust and collector systems.
   h. Drains for liquid splash.
   i. Provision for storage.
   j. Transportation of the raw material and the finished product.
4. Efficient sequence of operations to avoid "bottle-necks."
5. The cleaning of windows, skylights, overhead equipment, ceilings, walls, roof trusses, and so on.
6. The elimination of ledges and other dirt catchers.
7. Safe and efficient cleaning methods, as vacuum cleaning, wet sweeping, scrubbing, and cleaning tools and equipment, cleaning compounds, and so on.
8. Adequate and safe provision for painting.
9. The marking of aisles and storage areas.
10. Scheduling cleaning to get adequate cleaning without interference with production.
11. Protective equipment for cleaners such as belts, gloves, boots, and goggles.

A large proportion of fires in plants are due to poor housekeeping. Oil-soaked rags and clothing ignite from spontaneous combustion. Dust collectors not properly cleaned similarly cause fires. Inflammable and combustible materials help feed the fires once they start.

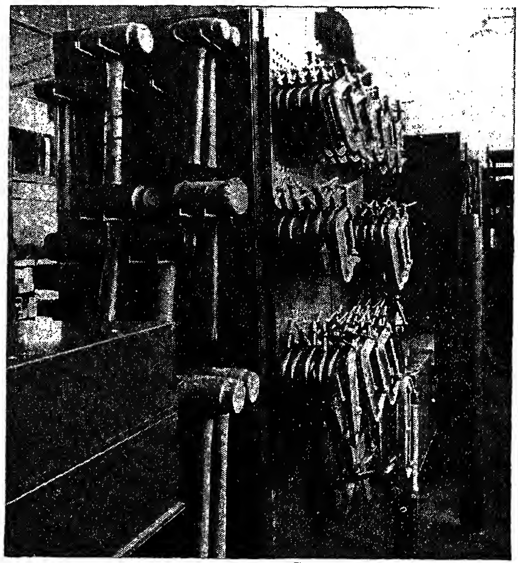
In general, orderliness and cleanliness in a plant presupposes that management has supplied or provided:

1. Storage places for materials.
2. Cabinets and holders for tools and portable equipment.
3. Containers for materials in process.

4. Prompt removal of materials and refuse.
5. Clean place for the workers to change clothes and wash.
6. Careful training of the employee.

Often inadequate planning for the handling, storing, and placing of materials causes delay or congestion that upsets the sequence of operations and yields a state of disorder.

Tool housekeeping is very important. The average plant uses a great variety of tools most (or all) of which are furnished by the company. Close control of their issuance and use saves tool cost. Tool maintenance is normally included in tool-room control, but maintenance that is reasonably satisfactory for production needs

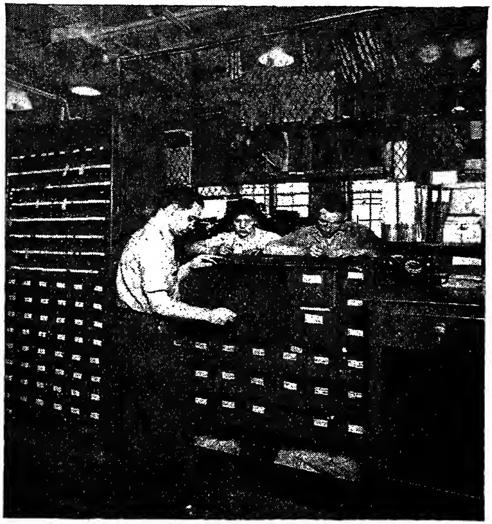


Courtesy of General Electric Co.

Clamp and mallet storage.

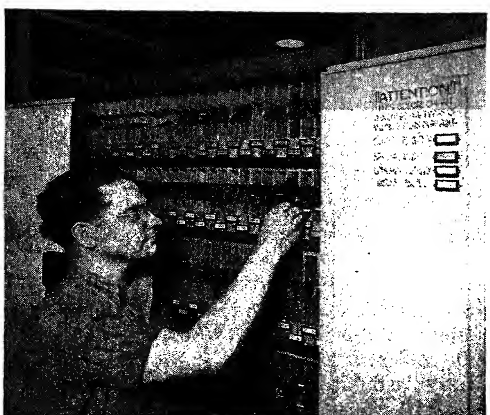
may not be adequate for safety. For example, one can do good work with a chisel whose head is mushroomed, but failure to prevent mushrooming of "struck" tools is a prolific source of injuries, chiefly to the eyes.

Good tool housekeeping is important both in the tool crib (or tool room) and on the job. Orderly arrangement of tool crib, suitable and adequate racks, pens, and holders, and an orderly



Courtesy of General Electric Co.

A place for everything and everything in its place.

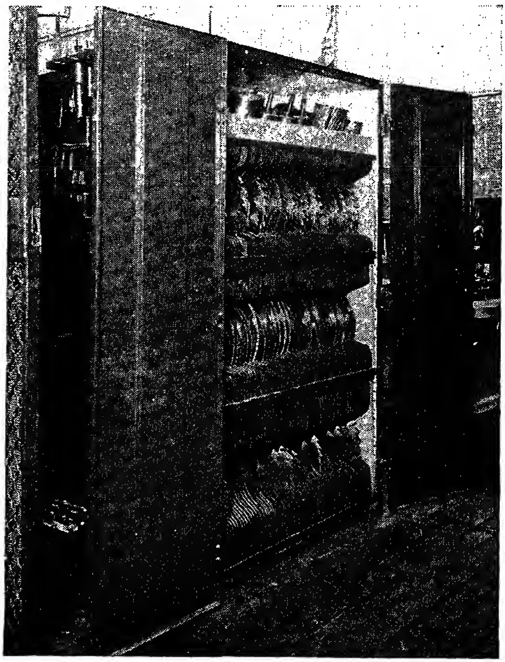


Courtesy of General Electric Co.

Tool crib storage for milling cutters.

routine in checking in and out, inspecting, repairing, and handling are essential.

At each machine and work bench, there should be a suitable holder or place for each tool, jig, or part used. In many plants, at least the heavier of such tools or parts and those subject to damage are kept on special wheeled racks which are returned to the tool room at the end of the shift.



Courtesy of General Electric Co.

Storage of saw blades.

Workmen should be taught to lay out their tools on each job in an orderly fashion. The workman who does this, having a definite place for each tool and keeping each tool in its place when it is not in his hands, will do more and better work and will be less subject to accidents.

The accompanying pictures are typical of good tool-room housekeeping and control.

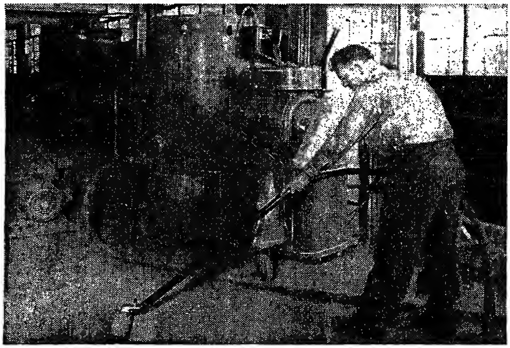
Disposal of scrap. If suitable and convenient containers for scrap and waste are provided, and if the workers are trained to use them instead of letting the floor catch all the waste and then spending time and energy to clean it up, expense will be saved, safety will benefit, and the factory will be a better place in which to work. A good foreman or production engineer can estimate the quantity of waste in advance and determine suitable means of collecting and moving it as it is produced.

Marking locations. Areas clearly marked and identified as aisles, storage spaces, receiving and shipping points, assist in keeping things in order. Often the condition of a department is upset not because of lack of space, but because someone has placed a skid or loaded truck in zigzag fashion; the next one is placed the opposite way, and, as a result, there is disorder and a wastage of space through simple failure to place the loads properly. Orderly arrangement also makes it much easier to remove the stored material or equipment.

Preventing spillage. Oily floors are a common accident and fire hazard. The primary effort should be to prevent the spillage by design and construction of equipment and its adequate maintenance. Splash guards should be provided wherever oil (or other coolant) may be thrown and drip pans wherever drippage may occur. The idea is to keep oil *off* the *floor*. This should receive careful attention in layout and planning.

Housekeeping and increased production. Under a demand for greatly increased production, the tendency is to "let down" on housekeeping including such things as the piling of materials and articles, cleaning of areas, keeping things checked up, and removing scrap and waste. This, of course, is conducive to accidents. If an operator requires a certain amount of space in which to work in ordinary times, surely he requires the same amount, if not more, when working under pressure for maximum production. Some firms find it desirable to have a decentralized system wherein each department has its cleaners, material movers, and others required to maintain good housekeeping and good order. This procedure is satisfactory provided these men are not taken from their regular work to do something else. They must, of course, be provided with whatever equipment or other aids are needed. Many firms use special clean-up men, who go from department to department in an ordinary routine to carry out their specific duties of cleaning windows, lamps, emptying waste cans, removing scrap, and so on. Both systems have their good points, and sometimes a combination of both is desirable.

Responsibility must be definitely placed as to who is to do the cleaning and what area he is to cover. Otherwise, out-of-the-way places such as roofs, overhead pens, shelves, yards, small buildings and sheds, cellars, basements, and boiler rooms, are overlooked until such time as they get into a deplorable state. It isn't unusual for the sweepers to say, "I was not told to sweep that



Courtesy of General Electric Co.
Clearing up the silica dust from a foundry floor with an industrial vacuum cleaner.

stairway"; and as a result, dirt and rubbish accumulate and remain until an injury calls forcible attention to the condition.

Management's part in responsibility

Management must take a definite part in the housekeeping program; and unless it accepts the responsibility not only of planning but also of enforcing consistently the measures decided on, good conditions will be neither secured nor maintained.

To begin with, the proper consideration must be given to orderliness when laying out the operations and processes.

Next, provision for specific facilities is required. A simple example of this might be the working area in a screw machine section:

1. Unless cabinets or shelves are supplied for storing the miscellaneous parts of the machine, the floor will be used.
2. The nature of the work in process produces chips that must be scrapped; therefore, suitable containers must be provided.
3. Oil used as a coolant might splash and, therefore, splash guards and oil pans will be needed.
4. Considerable raw stock will be used and provision must be made for storing this.

5. When the parts are machined, tote boxes must be available for them.

Setting up a plan in the executive office without arranging for proper supervision to see that it is followed up and carried out is often the cause of a poor result. It is essential that the foremen and other supervisors follow through and obtain the coöperation of all employees. Sometimes it is necessary to allow a few minutes during the day for cleaning up, but it is best to clean up as required while the job is in progress.

Courtesy of General Electric Co.

Ample light is conducive to good housekeeping.

Occasional grand clean-ups when an officer of the company or some other persons are expected do some good, but such spasmodic, hurry-up jobs would be unnecessary if a satisfactory plan were in operation.

Allowances for costs

Modern management, of course, realizes that suitable working conditions involve a certain amount of expense, which must be included in the cost of the finished product. This expense might include special features in the construction of the buildings and the necessary equipment for the carrying on of a cleaning program. Whether the work is done in part by the operators or by specially designated laborers or cleaners is incidental, the primary purpose being to secure satisfactory results with the most efficient use of time and expense.

Improving housekeeping by competition

We expect to find excellent conditions throughout the shop if the chief executives, supervisors, and foremen are sold on the

benefits of orderliness and cleanliness. In addition to this, it is, of course, necessary in order to attain any goal to have a plan which meets the specific essentials. For good housekeeping, the interest and coöperation of the supervisory group are absolutely essential, because it is this group that controls the conditions that they themselves create. The coöperation of the rank and file is also essential, but the supervisory personnel must provide the initiative and the leadership.

Many firms have found that competition of some kind, which stimulates thinking as well as action, goes a long way toward bringing about improvement. In making use of competition, or special drives, committees are appointed to make inspections. These may consist of an executive committee, a rotating committee of supervisors, a combination of supervisors and other employees, or representatives of the safety committee.

Inspection may be made weekly, semi-monthly, or monthly at irregular times so that clean-up squads cannot get busy just before the inspectors arrive and then let down on the job until the next inspection is expected.

System of penalties or awards

Many variations of penalties, such as Sloppy Joe, White Elephant, Mr. Pig, Dirty Maizie, or other derogatory symbols, may be used for the worst department. This undesirable character is usually placed in the department for a week or two and then abides its time for an unwelcome visit to another sloppy section.

If a symbol of uncleanliness is used, extreme care must be taken to avoid ridiculing or belittling the foremen and employees. The problem is to stimulate action in the right direction in a friendly, coöperative way, which, of course, requires a certain amount of sportsmanship.

Spic and span. Too often we criticize severely but fail to build up a desire for improvement because of the absence of an outward sign of approval.

To meet this situation, it is considered desirable to recognize the best department in some manner. Characters such as "Spic" and "Span" or a sign serve this purpose very well. This symbol of cleanliness should not be removed from the department, as are the derogatory symbols, because the idea is to keep up the spirit of efficiency by a symbol or some other tangible medium. Of course, if the department has let down, the penalty might be the removal of the trophy. If a trophy is presented every two weeks or every month to the best department and left there, the goal might be to have one in each department in the plant.

As a stimulation of interest on the part of the employees receiving the recognition, a gift, such as a pair of safety shoes, wallet, fountain pen, or the like, might be made to one or more of the employees. Placing all the names in a hat and drawing for the lucky winners is a simple procedure to follow. This drawing should take place at the time the manager presents the trophy and commends the group.

Courtesy of General Electric Co.

"Spic" and "Span," awarded for good housekeeping.

"Sloppy Joe," awarded for bad housekeeping.

A plan of this kind stimulates thinking on the part of the supervisors and leaders and inspires them to develop of their own initiative such improvements as:

1. A plan for good housekeeping.
2. General instructions for the group.
3. A study of work habits of the men.
4. A constant check on performance of the men.
5. Applicable signs, bulletins, and slogans.

Housekeeping inspectors

In order to assist the inspectors, an inspection check list is sometimes prepared. This is used most often where the employees make the inspection. A form of this kind is shown on page 134.

When supervisors inspect, a simple form is used, which covers general conditions rather than detailed items.

Inspector's report

Making an inspection and rating a department is not in itself sufficient. Inspectors are expected to make written reports of unsatisfactory conditions with recommendations for improvement. A typical report might be as follows:

HOUSEKEEPING INSPECTION MADE ON JANUARY 1, 1943

INSPECTION MADE BY: Henry Smith, John Jones — DEPARTMENT: Machine Shop #24

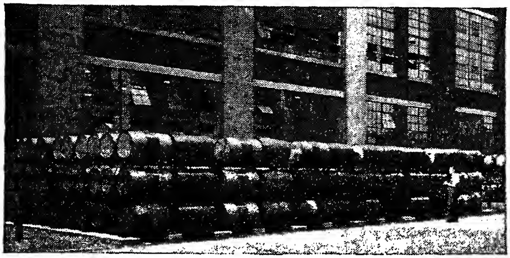
Item	*Section*	*Complaint*	*Correction*
1	22	Top of cabinet.	Foreman will have parts stored in cabinet.
2	8-F	Bar stock on floor.	Foreman had removed.
3	8-F	Chipper's portable screen needs repair.	Bench hand will do.
4	5-3	Light extension cord in poor condition.	Electrician will repair.
5	3-M	Front welding booth dirty.	Foreman to have cleaned.
6	4-M	Large jigs not stored.	Foreman will attend.
7	3-M	Base of column covered with loose material.	Foreman had removed.
8	1-M	Broken place in floor.	Laborers to repair.
9	16-2	Oil leak from gallery.	Maintenance will locate and stop leak.
10	5-1	Too many rags in operator's cabinet.	Foreman will have removed.
11	6-1	Chip guards on mills not in use.	Foreman to see that guards are used.
12	12-1	Rubbish under ladder of boring mill.	Foreman will have kept clean.

Why should we have good housekeeping?

A clean and orderly place makes employees respect the company, plant, and working area. It assists in improving the quality of the products, the efficiency and safety of the worker, his morale and pride. A customer or visitor has more confidence in an organization when he finds things properly taken care of.

Orderliness in the working area is conducive to orderliness in the thinking area of the individual. It is the foundation of good

working conditions and goes far toward reducing fatigue. Clean and attractive areas inspire the worker to keep things clean. A dirty, dark area attracts refuse and other material.



Courtesy of General Electric Co.
Drums of liquids stored in tiers by means of fork trucks.

The form shown below is typical of that used in rating the various departments. Basic to the fair and effective use of any rating system is a quite clear understanding by each member of

RATING FORM

Inspection form to be returned to J. Jones on 1943

Department Building Floor Foreman

This department is rated as follows:

	Maximum Points Allowed	Rating
1. Safety	25	
2. Orderliness	25	
3. Cleanliness (include washrooms)	25	
4. Loose parts on floor, waste and scrap around	10	
5. Appearance and condition of equipment	10	
6. Condition of aisles	5	

We recommend attention be given to the following:

Inspected by:
Signed ...
Signed ...

Date.

PLANT HOUSEKEEPING INSPECTION CHECK LIST

COMMITTEE .... DATE ....

GROUP .... DEPARTMENT ....

1. *Buildings:*
   a. Are walls clean for this department? ....
   b. Are windows clean for this department? ....
   c. Are walls free of unnecessary hangings? ....
   d. Is proper light provided? ....
   e. Are platforms in good condition? ....
   f. Are stairs clean and well lighted; have they standard rails and standard treads? ....
2. *Floors:*
   a. Is floor surface good for this department? ....
   b. Is it swept clean, free of loose materials, and is it clean in the corners, back of radiators, along the walls, and around the columns? ....
   c. Is it free of oil, grease, etc.? ....
   d. Are operating floors, or work positions, free of loose stone, scrap, metal or other materials? ....
   e. Is the building free of unnecessary articles? ....
   f. Are receptacles provided for refuse? ....
3. *Aisles:*
   a. Are aisles free of obstructions? ....
   b. Is there safe and free passage to fire extinguishers, fire blankets, and stretcher cases? ....
   c. Is there safe and free passage to work positions? ....
4. *Machinery and Equipment:*
   a. Is it clean and free of unnecessary material or hangings? ....
   b. Is it free of unnecessary dripping of oil or grease? ....
   c. Is position around it clean and free of rags, paper, etc.? ....
   d. Are lockers and cupboards clean and free of unnecessary material, both on top of them and inside of them? ....
   e. Are benches and seats clean and in good condition? ....
   f. Are drinking fountains clean? ....
   g. Are toilet rooms clean and well ventilated? ....
   h. Are proper guards provided and in good condition? ....
5. *Stock and Material:*
   a. Is it properly piled and arranged? ....
   b. Is it loaded safely and orderly in ships, cars, trucks, etc.? ....
6. *Tools:*
   a. Are they properly arranged in place? ....
   b. Are they free of oil and grease? ....
   c. Are they in good working condition? ....
   d. Are tool rooms orderly and clean? ....
7. *Grounds:* (Fifteen feet from outside wall or to first railroad track)
   a. Is yard outside building free of refuse such as fruit peelings, scrap, wood, iron, etc.? ....
   b. Were winter hazards checked? ....

the rating committee of just what is to be regarded as justifying an award of a maximum score and also what deductions are to be made for the various faults found. It is usually best at the start to set the standard not very far above conditions in the best department; gradually it may be raised as general improvement is secured.

REVIEW

1. Prepare a housekeeping inspection check list suitable for the plant in which you work.

2. What are the advantages of marking off areas and aisles? Painting lines on the floor?

3. What is the relation of scrap to fire prevention?

4. What are the advantages of good lighting as it relates to housekeeping?

5. Name five accidents that you know of that were due primarily to disorderly conditions.

6. A certain department is very poor in housekeeping. Write a letter to the foreman explaining the advantages of keeping his department in order.

7. Make a comparison of a centralized cleaning department vs. a decentralized one. Is it better to have the cleaners under the supervision of the department foreman or to have all cleaners under one head?

8. Do you favor contests to improve housekeeping? Why?

CHAPTER XIII

Maintenance

The proper maintenance of plant and equipment is essential to continuity of production. Satisfactory operating results are contingent upon having buildings, equipment, machinery, portable tools, safety devices, and the like, not only in operating condition, but maintained in such manner that they can be relied upon not to delay production or make it necessary to stop work to make repairs.

Good management does not permit the practice of merely good enough maintenance to keep things usable. Instead, its policy is one of anticipating deterioration and setting up overhaul procedure designed to correct defects as early as possible in their development. This obviously requires close integration of maintenance with plant inspection.

Poor maintenance causes accidents

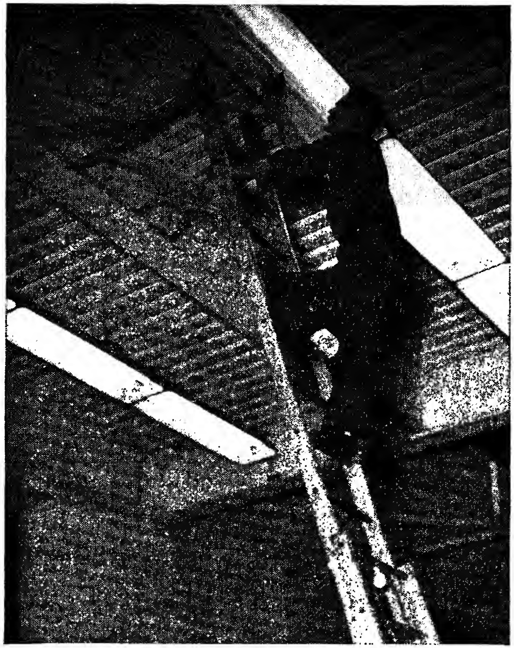
Many accidents and injuries are traceable to the character of maintenance. Instances in which this may lead to accidents or injuries are mentioned by R. P. Blake[1] as follows:

1. Floor maintenance. Roughness, slipperiness from wear, holes, splinters, and poor patching contribute heavily to the two classes of injuries that are commonly most numerous, namely "handling" and "slipping, tripping, and falling." Also such defects often contribute to "machinery" injuries.
2. The condition and design of all portable equipment on which men climb or stand or from which they work is important from a safety standpoint. This includes portable ladders, steps, horses, scaffold planks, and the like. Unless the management is actively interested in safety, such equipment may not be well maintained.
3. Tools defective through use are prolific sources of injury. This applies not only to the familiar hand tools, as chisels and wrenches, but also, because of their increasing use, to powered hand tools as grinders, drills, and so on.
4. Unless properly maintained, machine guards and safety devices not only fail to protect but, through giving a false sense of security, may be worse than no protection at all.
5. A higher standard of maintenance than is necessary for ordinary production may be vital to safety. For instance, clutch or shifter wear may cause unexpected starting of a machine.

[1] "Industrial Safety Subjects," Division of Labor Standards, United States Department of Labor, Washington, D.C.

6. Electric wiring becomes unsafe not only through use but from temporary repairs, alterations, or additions. "Temporary" jobs tend to become permanent unless carefully limited to necessities and immediately made standard when the emergency has passed.

7. A high standard of maintenance is necessary for elevators, cranes, slings, chains and tackle, pressure vessels, extension cords, portable motor-operated



Courtesy of General Electric Co.

Special ladder for lamp trimming. Top support secures ladder and insures correct position.

tools, and personal protective equipment. For this type of equipment, a definite schedule of inspection should be worked out and rigidly adhered to.

Qualifications for a maintenance man

Since repair men are exposed to many hazards because of the nature of their work, it is necessary that they be carefully trained and alert to all situations.

Some repair men who are good mechanics cannot work in elevated positions and should, therefore, not be requested to work

aloft. Frequently, repair men work in close proximity to moving parts of machines. The extraordinary hazards involved in tearing down and setting up equipment makes it necessary that they consider the safety of themselves as well as of others and make provisions to meet the situation at hand.

Maintenance men should be supplied with personal protective equipment suitable to the job at hand. This might include goggles, life belt, gloves, safety shoes, gas masks, respirators, hard hats, special clothing, and the like.

On hazardous work, men should not be permitted to be alone. Such work should include work on electric circuits, in gaseous areas, in tanks, at high points, and in out-of-the-way places.

It is necessary that repair men follow the safety rules of the organization, such as: (a) opening switches and locking the levers so that they will not be closed while working on the equipment; (b) using proper scaffolding, suitable ladders; (c) making certain that men are not working below when there is danger of dropping tools or parts; (d) using proper slings and hitches when hoisting; (e) placing signs or roping off areas when necessary; (f) considering the safety of themselves and of others.

Analyzing the job

The chapter, "Job Analysis," gives the details of breaking down a job into its component parts. If this is done properly, the job will have:

1. Careful planning.
2. Suitable equipment for the work available.
3. Hazards anticipated and provision made therefor.
4. Necessary supervision, if needed.
5. The proper selection of the men for the job.

Unfortunately, many accidents occurring during a maintenance job are overlooked because they do not result in injury to the worker. Examples of these follow:

1. Moving machinery; crane cable breaks, dropping machinery. Damage to the equipment but not to person.

2. Heavy loads being transported on factory trucks break through floor and tip over.

3. Ladder placed without being secured or bolted slides down.

4. Load on crane not raised high enough crashes into other equipment.

5. Drain cock in tank breaks off and oil or other liquid flows all over the floor.

6. Material, tools, parts drop from above.
7. Dust collector catches fire.
8. Short circuit on wires.
9. Overloaded crane breaks cables.
10. Falling from scaffolding without injury.

Why is maintenance conducive to safety?

Generally speaking, if machines, equipment, and safety attachments are properly maintained, we have more efficient operation, longer life of all the parts, fewer work stoppages, and a reduction in the number of accidents and injuries. For the present, let us concentrate on how to insure the safety of the worker. An employer finds it advantageous to provide properly designed and constructed guards for all dangerous places and for all machines whose operation unguarded is dangerous. In order to get the best results from these devices, their use must be insisted upon and they must be kept in proper working order. Only by this means can we eliminate the practice some employees follow of removing or even scrapping a guard and giving the excuse, "It was not working anyway." Typical examples of the relationship of maintenance and safety are:

1. A single action safety device for a punch press has a key part which, if broken, will allow a continuous stroke, thus removing the desired protection.
2. A worn steel spring used to disengage a clutch may allow the clutch to become engaged and the machine to operate unexpectedly.
3. Loose nuts and bolts on any equipment might, as time goes on, allow parts to drop off and get caught in gears or other moving parts.
4. Dust collectors not cleaned regularly are prone to spontaneous combustion, often with explosion.
5. Ordinary switches exposed to oil and water or dirt soon burn or blow out.

The history of defective ladders tells of an extreme number of injuries. Faulty arrangements for oiling equipment are responsible for many accidents. Maintenance and replacement of electric leads is essential to prevent short circuits. Maintenance of various valves, particularly of those used on acid tanks or others containing inflammable liquid, prevents leaks with their various hazards. Eyes or hooks used for attaching the window cleaner's belt require attention to protect the cleaner.

Extraordinary maintenance requirements

The list of conditions to be corrected and searched for with a view to remedial measures is endless. We generally think of maintenance as oiling machines and making necessary repairs to broken parts; but we sometimes overlook the need of taking some machines apart periodically and making a careful inspection and check of shafts, gears, and other parts in order to locate such defects as developing cracks, crystallization, and wear. An especially high standard of maintenance is required for equipment whose failure can be particularly serious, such as:

1. Electric hoists and cranes.
2. Hooks, chains, eye bolts, slings, and cables.
3. Pressure vessels.
4. Elevators and other equipment in which failures involve a great hazard. Usually these are inspected by specialists on the specific type of equipment involved.

In a large plant which contains many machines of a similar nature, such as punch presses, millers, lathes, and boring mills, certain maintenance men are selected to concentrate on a specific kind of machine and thus become specialists in their particular field.

How to appraise maintenance

A complete study of the operations relating to maintenance in a plant requires considerable time and a detailed knowledge of safety, including engineering technique. The average inspector, however, can observe the following, which are valuable indications of the effectiveness of the program:

1. Hand tools. Know the condition of those in use at the machine and on the benches. Is there a system of replacing or repairing defective tools?
2. Electric wires, control switches, and boards. Are these kept in first-class condition and is temporary wire eliminated?
3. Listen to the sound of operating equipment. A safety man soon becomes accustomed to the tune of equipment, all of which have characteristic and recognizable operating sounds. He can then tell when a machine is overloaded by the noise, the grunt, the squeal; whether maintenance is required because of the rattle and vibration. Visual observation, also, tells much.
4. A running record of the inspection dates, together with a list of difficulties found, is important, particularly as it affects

everything pertaining to electric cranes, elevators, pressure vessels, and guards.

5. Often a system has been set up for periodic inspection, but it is not functioning.

6. Indications of a poor maintenance program usually point to high maintenance costs and high injury rates. If a condition of this kind is found, it is important that the attention of an executive group be called to the facts in order that steps may be taken toward a remedy.

It should not be difficult to convince management that mass production is possible only with good maintenance and that mass safety is impossible without definitely including in the program of maintenance the upkeep of such things as guards, cables, safety devices, scaffolding and ladders, and other protective equipment.

Consideration must also be given to the time usage of the machine. Some machines are used eight hours a day; others, twenty-four hours a day. Obviously, the age of the machine or the actual hours it has been used, as well as the number of hours per day that it is in use, predetermines the maintenance or inspection cycle.

Since maintenance accomplishes the preservation of the normal and expected condition as against the abnormal, unexpected, or accidental situation, the effectiveness of the program is predicated not only on a repair program, but also on a preservation program. Maintenance is tied in very closely with operating supervision, depreciation from use, abuse, and fatigue. The machine operator is concerned primarily with the production output, which he gets by operating the machine through its controls. The inside working parts are generally left for the maintenance department to attend to. This same condition holds true of all kinds of equipment, buildings, hardware, trucks, sprinklers, and fire-controlling apparatus. The advantages of a periodic tear-down of equipment for close observation, as well as of continuous systematic visual observation of all exposed parts and safety devices, are extremely important.

Since maintenance men generally work in departments other than their own, the tendency is to avoid cleaning up after completing a repair or overhaul job. A maintenance job is never complete until the entire area is restored to order and particularly until the machine or equipment worked on is back in full operating condition with all safeguards in place and clean and ready to run. "He left the guard off" is far too often the finding of accident investigation. Holes made in the floor should be repaired,

loose material and articles removed, equipment taken away, grease or oil cleaned up, and so on.

REVIEW

1. What part does maintenance play in an accident-prevention program?

2. You are an inspector and wish to determine the effectiveness of a maintenance program. How do you proceed?

3. Mention five important items in the maintenance of electrical equipment.

4. Mention five items on which an especially high standard of maintenance is required.

5. The sound of equipment sometimes indicates the need for maintenance. Mention five conditions of this kind.

6. Why is it necessary that maintenance men be especially trained in accident prevention?

7. Mention three accidents that could be traced to faulty maintenance.

8. Do you think injuries as a result of faulty maintenance are more serious than the average? Why?

9. How can the safety man assist the maintenance man?

CHAPTER XIV

Handling Material

The subject of handling materials is an exceedingly broad one. All raw materials, parts, material in process, finished products, scrap and wastes used or produced in industry must be handled. The means used, therefore, must vary to meet such factors as character of material, size, weight, rate of handling, distances moved, the purpose of moving or handling—to mention a few. The methods and procedures used vary not only as between plants but also as between departments within a plant, so that, while the handling of materials is an important function of overall planning, the needs and problems of each department also must be studied in detail and suitable methods decided upon.

The reports of the agencies administering workmen's compensation acts show that on the average at least 25 per cent of compensable injuries in the manufacturing industries are connected with the handling of materials and objects. Accident experience also shows that the substitution of suitable mechanical means of handling for manual methods reduces accidents greatly. Also, it is faster and more efficient; and, if the relationship between volume of goods moved and the cost of the equipment required is within proper limits, the unit cost of moving will be favorable also. This factor of volume of material to be handled is vital, for even in the most modern best-planned and best-equipped plant, much lifting, carrying, and handling must be manual in whole or in part.

Since the subject is so big, this discussion is of necessity limited to certain phases of it that are of major importance to safety.

Methods of handling objects

General methods (in addition to hand handling) of moving material commonly used in industrial establishments, both large and small, are briefly by:

1. Hand lift trucks.
2. Dragging or sliding on skids or rollers.
3. Wheelbarrows.

4. Hand trucks, power trucks, and tractors.
5. Hoisting apparatus.
6. Overhead traveling cranes.
7. Conveyors.
8. Mechanical shovels.
9. Elevators and escalators.
10. Chutes (gravity or under pressure).

The basic fact that the unsafe acts of individuals are a factor in the majority of accidents justifies of itself the substitution of mechanical for manual operations wherever practicable. This statement implies, of course, that the mechanical means used must be of safe design and construction, suited to their purpose, thoroughly guarded, properly maintained, and that the personnel selected to operate them be properly qualified and adequately supervised. Typical hazards of the use of such equipment are overloading, poor arrangement of material, operating at excessive speed, lack of adequate space for operation, lack of skill, and improper attitude on the part of the operator.

Safe practices and methods should be applied

Those responsible for, and those who do, the actual work should have a knowledge of safe practices as well as methods. Following are some ways to prevent accidents and injuries:

1. Men should lift with the leg muscles, keeping their backs straight and their knees bent. One man should not attempt to lift an object alone if two men are required for safety.

2. When very heavy or long objects are carried by two or more men, teamwork and motion in unison is essential. One person should be leader and direct the work. Special tools should be used whenever possible. Sometimes a whistle is used for giving signals for lift, walk, and let down.

3. In handling long material such as pipe, lumber, and ladders, the front end should be held high and the rear end low. This is done so that the front end is above the height of a person when turning blind corners.

4. A very heavy object should not be raised by hand if a crane, hoist, or other method is available. Such objects, especially if odd in shape or bulky, may get out of control and cause an accident.

5. When rolling tanks or other heavy round parts either up or down an incline, the motion should be controlled with ropes or tackle, and men should never stand on the downhill side.

6. Since many handling operations consist of loading and unloading near machines or processes, safe practices are likely to be overlooked because the piling is temporary. Actually, the hazard may be greater in such a location than in a warehouse. Even were the hazard slight, bad piling establishes a precedent which later leads to injuries. Therefore, piling should always be properly done.

7. Tools and equipment such as shovels, forks, crowbars, wheelbarrows, hand trucks, cant hooks, and other handling gear should be kept in good operating condition.

8. Protecting the hands by gloves, leather pads, and the like, and protecting the feet by safety shoes and foot guards are of value when handling lumber, metal in various forms, boxes, and any other articles heavy enough to injure the feet.

9. Holes and unevenness in floors cause material to be shaken from loaded trucks.

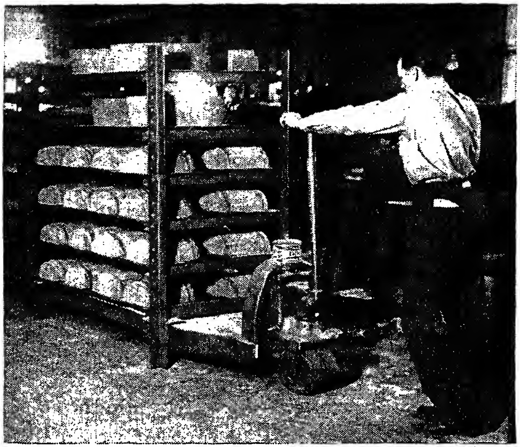
10. Aisles should be clear and wide enough to allow amply for all traffic they are called upon to carry. Sometimes traffic should be rerouted.

11. The piling of material must include proper tiering and securing, as well as proper provision for its safe and efficient removal. Supervision and training must include safe means of its removal. Material piled for unpiling from the top may become unsafe if removed from one side.

12. When using wheelbarrows, the load should be placed well forward to make it easier to lift and push the barrow. Overloading should be avoided and the runway should be smooth, steady, and strong. Knuckle guards should be provided for passing through narrow doors or between columns.

13. Proper slings should be used and placed correctly when making a lift. Loads should be secured to prevent tipping and sliding.

14. Hand lift trucks are in general use throughout industry. It is important that the proper type of truck be selected for the task and that it be kept in good condition. Care must be exercised to keep the center of gravity of the load as low as possible to prevent tipping, shifting, or falling off of material. Push, rather than pull, should be the rule. Handles should be left in a vertical posit on when not in use so that no one will trip over them. Counter weights, springs, or hooks may be installed for this purpose. Maintenance is particularly important with the hydraulic hand lift trucks to prevent "dropping" the load. If a brake can be applied to advantage, this should be done.



Courtesy Yale & Towne Mfg. Co.

Hand lift truck elevates load to be moved.

Industrial trucks

Industrial trucks usually powered by storage batteries or internal combustion engines are used extensively in industry for the handling of materials to and from stockpiles, to and from machines, and on through to warehouse or loading platform or car. These trucks are of many types, weights, and capacities. Some weigh several tons and have a capacity of several tons. The power is carried through simple operating controls to the travel motors which drive the truck and operate the lifting devices at the will of the operator.

The platform type, which is used to carry the load from one place to another, requires either manual or mechanical handling for loading and unloading.

The elevating type of platform truck makes use of a skid on which the load is placed. The platform is inserted under the skid, elevated to lift it from the floor, and the truck carries it to some other point.

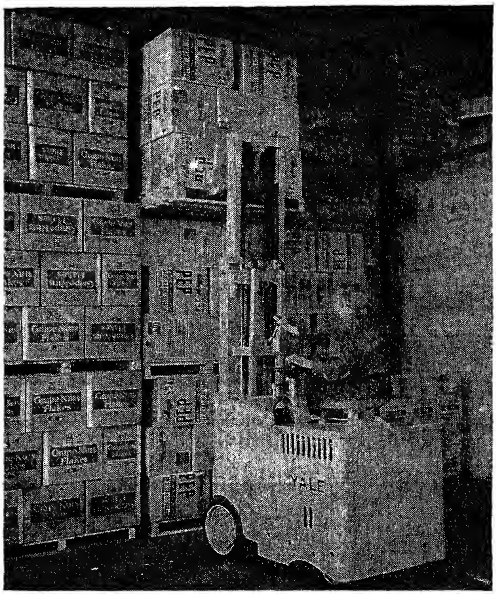
The fork lift truck makes the lift by means of a two-prong fork instead of a platform. It is designed to lift the load up to about ten feet from the floor, permitting high piling to conserve space. Since this involves heavy floor loading, floor strength must be considered when planning for the use of these trucks.

Courtesy General Electric Co.

Steel drums delivered by a platform truck and piled with a fork truck.

Courtesy Yale & Towne Mfg. Co.

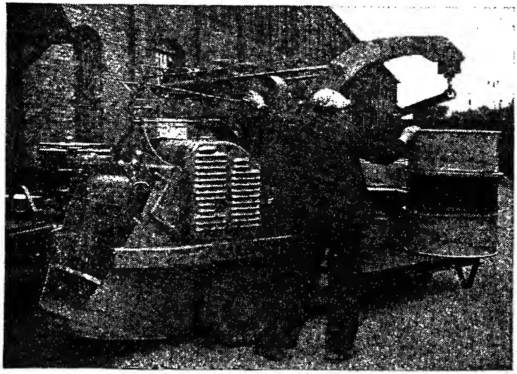
Fork truck used to tier skids.



Courtesy Yale & Towne Mfg. Co.
Fork truck used to tier pallets.

Courtesy Yale & Towne Mfg. Co.
Scoop truck for handling stone, coal, sand, and so on.

Another type of truck simply acts as a tractor to pull trailer loads of material.



Courtesy Yale & Towne Mfg. Co.

Platform truck with hoist and fixture for handling drums.

Courtesy Yale & Towne Mfg. Co.

Fork truck with attachment for loading trucks and cars.

Generally, the supervision of the trucks and operators is centralized in a transportation department and the operators have specific assignments. The flow of material is controlled by job tickets which indicate where the material is to be placed. In large organizations, it has been found satisfactory to have an

incoming and outgoing material bay. This allows for a general delivery point from which the department men convey the material to the specific point. When the work is completed, it is placed in the outgoing bay if it is to be consigned to another department. Thus, the general transportation department operator comes in with a load, deposits it in the incoming bay, checks the job tickets, and takes a load out with him.

The smooth flow of material is so vital a part of production that the careful selection of the operators of these trucks in the interest both of efficiency and safety is an important matter. Some plants find it best to license all truck operators after first giving them special training in the operation of the truck, the routine to be

Courtesy Yale & Towne Mfg. Co.

General-duty truck with boom hoist for handling castings.

followed, and the rules and regulations to be observed. The method used is similar to the procedure in licensing an automobile driver and includes an operation test, a verbal quiz, and registration. A truck operator's badge must be worn when operating the truck.

Racks for tiering skids

The primary function of fork trucks or other elevating mechanisms is to place skids, drums, bales, or pallets either in racks or on top of each other in order to save storage space. Skid turning racks aid stability and give greater flexibility. They provide for the placing of two, three, or four skids one on top of another on a

rack or track so that the lower skids may be removed without disturbing the upper ones. They are used in stock rooms, accumulation areas, machine shops, fabrication shops, and outdoor storage. By proper planning and layout of floor space, utilizing wherever possible existing aisles and open area ways, more material can be placed in a given area, and each unit load is readily accessible at all times.

Miscellaneous methods of handling material

Far-seeing supervisors will plan to use special tools and fixtures to simplify the handling of materials used in their department. Examples of these are:

1. A tote box handle which is attached to the tote box so that it can be dragged along the floor.
2. A special fixture in which to place compressed gas cylinders so that they can be lifted or hoisted on a crane.
3. Car movers.
4. Rope used for snubbing to act as a brake when unloading heavy drums from trucks.
5. Pike poles for rolling barrels.
6. Tongs and pliers for handling hot metal.
7. Hand hooks for freight handlers.
8. Hooks for rolling logs.
9. Rollers for heavy, bulky material.
10. Special slings.
11. Chain hoists.
12. Traveling, Gantry, and wall cranes.
13. Clamps for handling sheet steel, barrels, boxes, and so on.
14. Box car loaders.

Conveyors

Special conveyors and Monorail systems are used in many instances to eliminate manual labor, expedite the movement of material, and also to facilitate the processing or assembly. Examples of these are:

1. The automobile assembly line.
2. Conveyor systems on which to hang and move material to be painted so that the spraying operation can be done at the exhausted-spray booth.
3. Roller conveyors at certain points which allow for loading baskets and then passing them through the degreaser, washer, or dryer areas.

Improved methods as they apply to safety

If up-to-date improved methods are used in all cases of handling material, we remove, to a great extent, the human element by using mechanical devices to replace manual labor. This phase of plant operation is often neglected in spite of the fact that much time and money is consumed in the handling of materials. Such weakness decreases the efficiency of the organization and increases the number of accidents. The installation of proper methods, therefore, reduces the hazards as well as the cost. Frequently, allowance is not made for the growth of a plant or the changes in products and processes. Management becomes accustomed to the old methods and accepts their limitations. A competent safety man, in close coöperation with the methods or planning department, will examine with a critical eye the system in use with a view to improving conditions.

Typical indications of out-of-date or faulty methods are:

1. *Lack of orderliness.* Improper sequence of operations and arrangement of machines makes it necessary to move stock back and forth rather than in a direct line to the finished product.
2. *Lost material.* Lost material makes it necessary to provide additional expeditors or searchers to locate material in process which has gone astray.
3. *Manual lifting.* Any excessive amount of hand lifting of heavy objects indicates the need of such mechanical aids as lifting devices or special trucks.
4. *The absence of suitable traffic aisles or storage space.* Inadequate aisle space and insufficient storage space will inevitably yield disorderliness. Therefore, provisions for aisles and storage spaces and a place for everything are of prime importance.
5. *Skids, boxes, and containers overloaded or carelessly loaded.* This might indicate poor supervision, poor training, or lack of suitable containers.
6. *Equipment in poor repair.* This includes wobbly truck wheels, broken truck bodies, faulty power equipment, floors in poor condition, cables and slings worn, worn or broken tools, which indicate the results of lack of maintenance.

In most of the larger organizations we find that attention has been paid to these things. Establishments that haven't done so would benefit by paying more attention to symptoms of this kind. They would improve both safety and efficiency by applying suitable remedies.

Applying safety measures in handling materials

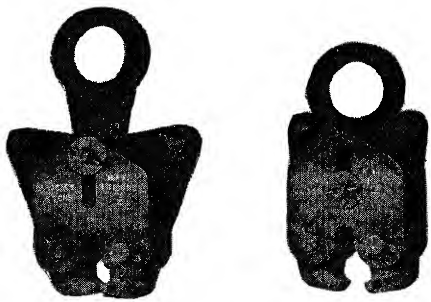
So many problems are involved in a subject of this kind that no one can deal with all of them. Searching out the obvious hazards and applying the corrective measures is definitely a part of the safety man's duties. Let us take a few examples of hazards and apply the remedy.

Operation, Hazard, or Injury	Preventive Measures
1. *Overhead crane load:* One-eighth inch steel plates, 60″ by 90″ slip out of crane sling. Man struck on head.	Proper binding of load. Crane load should never be passed over heads of workers. Arrangements made to warn workers, by bell or other signal, to get out of way. Use spreader for lifting this kind of load.
2. *Incoming railroad car:* Material jammed between side of building and car.	Proper clearances between sides, tracks, and fixed objects. Supervision of loading and movement of railroad cars, adequate lighting, reduction of speed, special training.
3. *Handling acid carboys:* Carboy broke, acid splashing on man. Possible injuries: burns, inhalation of toxic fumes, eye injuries.	Use trucks designed especially for acid carboys. Arrange for runway if necessary to get on platform. Assign duties to specific individuals. Provide adequate safety equipment such as goggles, rubber boots, aprons, rubber gloves. Provide shower bath for use in case of accident. Give special training and instructions as well as information regarding the hazards involved.
4. *Piling materials:* Falling materials, strains from lifting, falls, foot and hand injuries.	Special equipment for piling. Methods worked out to suit materials and conditions, training in proper way to lift and to pile materials, adequate storage space, orderliness, lighting.
5. *Handling stock or articles at machines or processes:* Abrasions, cuts, bruises and sprains of hands and arms, slivers in hands and arms, foot injuries, dermatoses, eye injuries from flying particles, burns.	Gloves (not on revolving equipment), wrist and hand leathers, aprons, safety shoes, goggles. Reduce handling by layout of machines and processes and by motion study and special handling methods suited to specific conditions.
6. *Emptying and cleaning tank cars:* Suffocation or poisoning on entering tanks, burns from acid drips, falls from cars, explosion of inflammable gases, electric shock from extension cords.	Testing of air in cars, steaming out, washing out, or ventilation of cars, use of fresh-air helmets, use of life line and watcher outside car, training, supervision, proper ladders, platforms, and tools and equipment, safeguarded extension cords and lights, protective clothing.
7. *Transporting materials and articles through the process:* Struck by trucks, hand pinched, torn or bruised under or between articles, articles falling on feet, falls over loose articles, strains, getting caught by powered conveying machinery.	Planned and routed traffic, clear aisles, trained power vehicle operators, hand truck of proper type, adequate spaces for placing at machines or other stations, housekeeping and order, complete guarding of all hazardous moving parts. Good maintenance of equipment and floors.

8. *Preparing for shipment:* Strains, tool injuries, falls. — Order training, proper equipment, adequate space, supervision.

9. *Opening baled, crated, or barralled material:* Cuts and abrasions from sharp edges; nail wounds, strains from lifting, tool wounds. — Adequate space for work, proper tools, training, supervision, housekeeping and order, hand, foot, and leg protection, lighting.

Automobiles and railroad cars play an important part in the delivery of materials. No mention has been made of details in connection with these important phases of material movement since they should be dealt with as a separate subject.

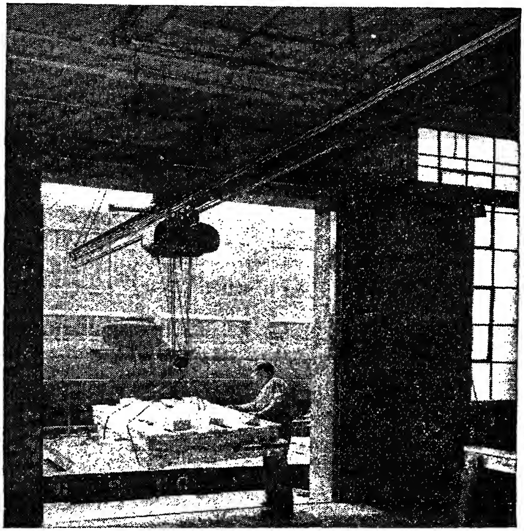


Courtesy General Electric Co.

Grip hook for handling steel plate. At left, closed. At right, open.

The engineer's part

Through engineering we have substituted mechanical power for manpower; mechanical feeding and handling equipment has replaced dangerous manual handling, which in itself is always slower and more costly. Workers thus released are available for more important jobs. Since the substitution of mechanical equipment for human labor reduces the number of men exposed to hazards, we automatically reduce the number of accidents and injuries because of this fact alone. If we continue to develop and train workers efficiently to apply the mechanical devices that have replaced manual labor, we can continue the downward trend of the accident rate. The results are contingent on proper supervision, training, enforcement, application, and maintenance of the various equipment used.

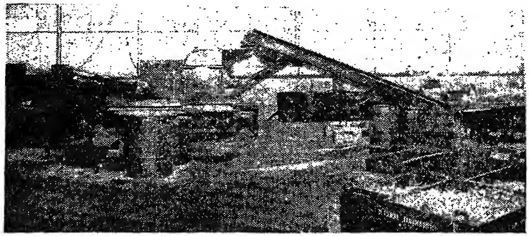


Courtesy General Electric Co.

Loading from warehouse to car with a mono-rail floor-operated crane.

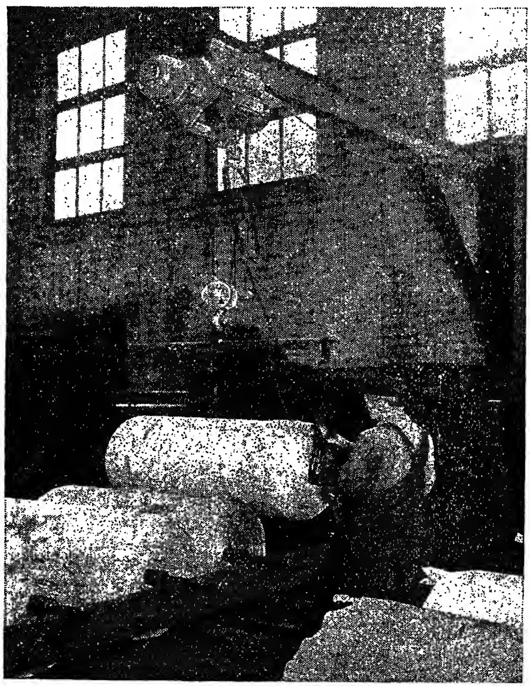
Courtesy General Electric Co.

Grip hook used in carrying steel plates with overhead traveling crane.



Courtesy General Electric Co.

Chip crusher and magnetic separator assembled as a unit being fed by a belt conveyor.



Courtesy Yale & Towne Mfg. Co.

Hoist with spreader handling rolls of paper.

Suggested procedure for management

1. Analysis of past injuries resulting from handling material.
2. Analysis of existing methods with a view to improving them.
3. Improved supervision and training of every worker, bringing to light the hazards involved in material handling.
4. Enforcement of rules and instructions in safe handling practice.
5. Checking up on the maintenance of material-handling equipment.

Following through with this procedure helps us to progress along well-founded practices and effective principles.

REVIEW

1. Why is it necessary to include accident prevention in material-handling operations?

2. Give five causes of accidents as a result of handling material with the remedy for prevention.

3. Why is it desirable to substitute mechanical for manual labor in handling material?

4. You have one department in which handling material is responsible for an excessive number of injuries. How would you approach a condition of this kind?

REFERENCES

For a more extensive discussion on handling material, the reader is referred to the following *Safe Practices Pamphlets* published by the National Safety Council:

No. 54, "Handling Material."
No. 55, "Industrial Power Trucks and Tractors."
No. 33, "Hoisting Apparatus."
No. 4, "Overhead Traveling Cranes."

CHAPTER XV

Hand Tools

Hand-tool injuries are relatively numerous in all branches of industry. Since they result from the use of tools that are defective or unsuited to the purpose, or from unsafe methods of use, corrective measures can be carried out within the department. Too often there is failure to appreciate the importance of keeping hand tools in good condition and of eliminating the use of the wrong tool for the purpose. The attitude of the supervisor in a large measure controls the practices and working habits relating to small tools within his department. All tools must be made safe, maintained in good condition, and used properly.

Hand tools are not ordinarily thought of as dangerous agencies likely to produce injuries. Also, it is generally assumed that the injuries they do yield will be minor in nature. Actually, the use of hand tools in the manufacturing industries as a whole and in many individual industries is a major source of injuries. *Accident Facts*[1] shows that in Pennsylvania during 1940 (presumably a typical year) 9.43 per cent of the total lost-time injuries reported to the Workmen's Compensation Board were charged to hand tools. Data from other states show similar proportions.

It is true that the proportion of permanent disability cases from the use of hand tools is low as compared to injuries from many other activities as, for instance, the operation of machinery. However, the total of serious injuries is still large. Flying particles from mushroomed heads, overtempered points, or the material being worked on, destroy many eyes and cause many puncture wounds to become infected and many fatalities to result from the use of electric-powered tools. Furthermore, the fact that the proportion of minor injuries (non-lost-time cases) is high means that a large total of working time is lost getting these little injuries treated. Hand-tool injuries can be prevented as definitely as those from any other source, and it is just as profitable to prevent them.

[1] Published annually by National Safety Council, 20 N. Wacker Drive, Chicago, Illinois.

Hand tools of one sort or another are used in every industry, more particularly in the metal-working trades, in maintenance and repair work, construction, logging, and lumbering. Some tools are common to all of these, as well as special tools peculiar to certain occupations.

Control of accidents

We can control accidents directly attributed to defective and improper hand tools, but we have more difficulty in controlling the action of the worker who might strike the tool a glancing blow, thus causing a piece of steel to fly at high velocity and strike his eye. The accident in cases of this kind cannot always be controlled, because of human imperfection, but the injury can be avoided by the use of goggles.

Hammers with corrugated heads help prevent the heads from glancing off nails. If crystallization has taken place in the head of a hammer, or a highly tempered piece of steel is struck, chips are likely to fly because of the brittleness of the material. Blacksmiths must use care in tempering all hand tools, particularly those used for chipping or similar operations, because of the danger of pieces breaking off and flying.

Because of this danger, all heat treating should be done by those skilled in the art, who understand the properties of the metals used and know how to apply the treatment required in each case. This point deserves emphasis, for up until the quite recent past, tools were made from a very limited range of carbon steels which any good blacksmith could temper properly. The last three decades have brought a multiplicity of steels which require specialized heat treatment. Also a much greater technical understanding of the crystalline structure of steels has been gained. Heat treatment is a highly specialized art.

Needless to say, material from which hand tools are made should be of good quality and appropriate for the use to which it will be put. A periodic inspection of all tools would include the collection of those that need dressing, repairing, and replacements. This work, of course, should be done only by persons qualified to do it. Tools not in use should be stored safely on racks or shelves designed for them or should be placed in tool boxes.

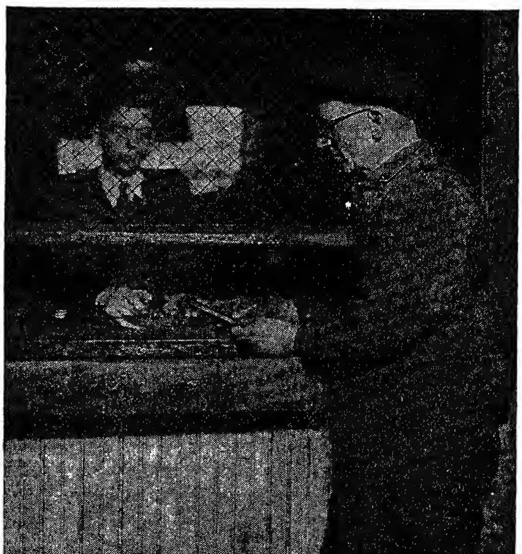
Use of wrong tool for purpose

At times the supply of suitable tools is not sufficient to meet the demand, and, in other cases, through lack of training or knowl-

edge, a tool in excellent condition is used for a purpose for which it was not designed. For example:

1. Machinist's hammer used for driving nails.
2. Carpenter's hammer used for hammering metal.
3. Drill sharpened for drilling steel used on brass or copper without removing the lip.
4. Screw driver used for a chisel.
5. Use of open-end wrench which is too large for the nut to which it is applied.
6. Knife used as a screw driver.
7. File used as a drift pin to remove the drill from the chuck.
8. Wrench used for a hammer.

Tools must be used correctly and for the purposes for which they are designed. Otherwise, we may expect accidents and injuries.



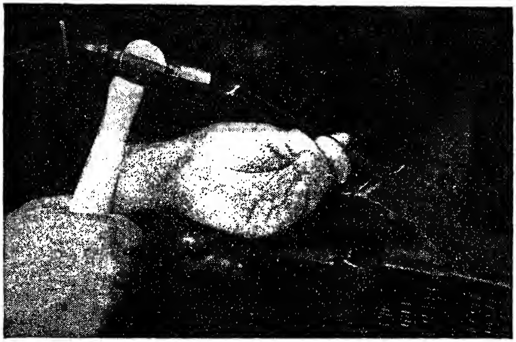
Courtesy National Safety Council.

Turning in a chisel with mushroomed head. Pieces can fly like bullets from such a tool.

Incorrect methods of using tools

Let us assume that we have a hand tool in excellent condition and are using it for the right purpose. The way we use it must be correct also to avoid accidents. For example:

1. *Sharpening a pencil.* Push the sharp edge of the blade away from the body.
2. *Use of monkey wrench.* Place the wrench on the nut in such a position that the pull on the handle tends to force the jaws further



Courtesy National Safety Council.

The proper way to hold a chisel. Knuckles are out of danger and the hand is held away from the chisel head.

onto the nut. This would ordinarily mean that the open jaws are facing you while you are pulling instead of pushing on the wrench.

3. *Chisels.* When chiseling wood or metal, do so in such a way that if the chisel should glance from the object it will fly away from your body.
4. *Draw knife.* Keep far enough away so that if the knife leaves the wood it will not cut your body.
5. *Hand saws.* Placing the fingers or thumb close to the blade when starting to cut is dangerous.
6. *Hatchets, axes, and adzes.* Fingers, toes, and other parts of the body must be well out of line with the swing of the tool so that injury from a glancing blow or a miss may be avoided.
7. *Pliers and wire cutters.* Ordinarily these are safe tools, but their use on or about live circuits results in many short circuits, burns, and shocks.
8. *Files.* Unless a handle is used to cover the sharp pointed tines, there is danger of receiving a puncture wound in the palm

of the hand or at the base of the wrist. Never hit a file with a hammer; pieces of the hardened steel are almost sure to fly. If used to pry with, it may break, causing pieces to fly.

Courtesy National Safety Council.

Hand saws jump if not started properly. The workman makes a long, slow cut upward, then moves his thumb away from the saw.

Defective tools

Following is a list of defects which may be found in the more common tools used:

1. *Chisels, punches.* Mushroomed or chipped heads, chipped or dull edges or points, overtempered heads and points, too short for hand safety.
2. *Mallets.* Uneven, worn heads, poorly secured handles.
3. *Electric-power tools.* Worn, deteriorated, or inadequate insulation; split or chipped plugs; worn or bent plug terminals; defective switch; vibration; sparking; wrong drill; projections on check; lack of guard (as portable grinder or saw); worn or insecure chuck (or other attachment device).
4. *Files.* Handles missing, chipped ends, teeth worn smooth or filled.

5. *Hammers.* Loose, split or rough handles, chipped or battered heads, sprung or broken claws (carpenter hammer), poorly secured handles (nails in place of wedge).

6. *Hooks.* Dull points, handles improperly shaped, leaving finger-pinching hazards.

7. *Knives.* Lack of finger guards, dull or nicked edges, loose or split handles.

8. *Lifting jacks.* Worn threads; ill-fitting or sprung safety pawls; inadequate base; sprung, ill-fitting or inadequate operating handle.

9. *Pick axe.* Loose or split handles, dull or bent blade, bent shank.

10. *Saws.* Improper set, sprung blades, loose or splintered handles, dull.

11. *Screw drivers.* Split or battered handles, dull or bent blade, bent shank.

12. *Shovels.* Split, rough, or loose handles.

13. *Tongs and pliers.* Poorly shaped, worn or chipped jaws, handles improperly shaped, leaving finger-pinching hazard.

14. *Wrenches* (pipe, monkey, end, and the like). Worn or sprung jaws; battered heads; rough, broken, or sprung handles; worn mechanism.

Special attention must be given to corrective measures in connection with these and other defective tools.

Tool-room control of tools

A safety-minded tool-crib attendant, properly trained and equipped to inspect and repair defective tools, is in an excellent position to prevent accidents. All tools should be issued from the tool room and returned to it periodically for inspection and repair. If this procedure is supplemented by an occasional inspection of the tools in use in each department, and if each foreman coöperates in his daily rounds, a good standard of maintenance and correct use can be maintained.

In some plants, the tool room has its own repair shop. In others, tools that need repairs are turned over to the section designated for this work, and, when reconditioned, are returned to the tool room for reissuance.

Purchasing small tools

The coöperation of the purchasing department to insure the ordering of equipment on the basis of efficiency and safety, as well as price, is necessary.

A central tool and planning department from which supplies for the department cribs are forwarded is generally used. This should be supervised by a man who has mechanical ability, a knowledge of tools and their usage, and who can foresee the application of them in the shops. He is charged with the responsibility for ordering suitable tools for the shop and his requests to the purchasing agent should specify the kind of tool to be ordered, and, if necessary, the catalog number.

This system gives greater assurance of the safety of design and construction, as well as of application.

Provisions for safe handling of tools

Annual expenditures for both durable and nondurable tools run into large totals in the average factory. In order to keep tools in good condition, it is necessary that suitable arrangements be made for storage within the tool crib, for transportation or delivery to the workers, and for suitable holders, shelves, or cabinets for them at the benches or machines. Sheaths or guards for edged or pointed tools are required, particularly where they are carried from one place to another by the worker, as in the case of ice picks, knives, and axes.

Mechanically operated portable tools

Up to this point, we have dealt with hand-operated tools. Power-operated portable tools require special consideration, since they present additional hazards. Following is a list of some commonly used power-driven hand tools:

Grinders.	Riveters.
Polishers.	Hoists.
Drills.	Portable exhausts.
Nut and bolt drivers.	Circular saws.
Chippers.	Small internal and external grinders.

These tools usually are submitted to a considerable amount of abuse as well as improper usage. In many cases, the point of operation can be properly guarded or other safety precautions taken in order to protect the operator. For example:

1. Every portable circular saw should be equipped with a guard that at all times encloses all of the teeth except those in the cut.

2. Grinding wheels should be equipped with a guard enclosing all of the wheel that the work permits and flanges of the proper

size over soft washers. Dropping or striking the abrasive wheel is hazardous.

3. Grounding the cases of electric tools by means of a third wire or central grounding through the receptacle is imperative in all cases, to prevent shock should the winding break down.

4. Powered nut and bolt drivers are difficult to control after the nut or bolt is driven home and, therefore, a release or stop should be provided.

5. The fan blades of portable exhausts should be enclosed.

6. Wherever possible, powered tools should be equipped with dead-man control so that if the operator loses his hold the machine will stop automatically.

7. Leads and hose lines should be protected from wear, sharp bends, and damage.

8. It isn't unusual for a man operating a portable air-operated grinder to change the governor in order to increase the speed. This, of course, produces overspeeding with the likelihood that the wheel will explode. The speeds of such equipment should be checked periodically.

Some of the special attachments for machines as, for instance, internal and external grinders used on lathes, require special precautions. Speed variations to allow the use of different sizes and types of wheels are secured by combinations of pulleys. Fatalities and major injuries due to bursting of wheels are on record because workers failed to comply with the instructions issued with these machines, indicating the proper pulley combinations for certain kinds and sizes of wheels. Overspeeding of five or more times safe speed is possible in many cases.

Safety men must recognize and become familiar with all portable equipment and make arrangements so that proper periodical inspections are made.

A worker properly trained in selecting the right kind of tool for the job, who uses it correctly and keeps it in good condition, should, under ordinary conditions, avoid accidents both to himself and to others.

A safety man or supervisor who checks up on the operation of a tool crib and inspects the equipment therein will find in many instances conditions which indicate the need of a more careful inspection, an improved purchasing system, and more intelligent use and application of the tools involved.

Supervisors sometimes overlook the importance of checking up on small tools and making provision for maintenance, safety, and replacement. This not only fits in with keeping costs and acci-

dents down, but also tends toward increasing production and quality.

REVIEW

1. Mention five causes of injuries associated with the use of small tools.

2. The human factor is an important element in preventing accidents while using small tools. Cite five examples.

3. What would you do to control the improper use of tools?

4. List five hand tools and indicate what you would look for in a safety inspection of them.

5. What place has a tool-crib attendant in accident prevention?

6. Mention five mechanically driven portable tools and the hazards peculiar to them.

CHAPTER XVI

Low-voltage Electrical Hazards

The subject of low-voltage electrical hazards is extremely broad. A large number of factors closely related to safety are involved in the transmission and utilization of electricity, such as design, installation, protective devices, inspection, maintenance, and training.

The 1942 issue of *Accident Facts* lists causes of occupational accidents connected with electrical equipment in Pennsylvania as follows:

Unsafe Act or Cause	*Per Cent*
Overloading, poor arranging	36
Unnecessary exposure to danger	10
Unsafe or improper use of equipment	31
Nonuse personal protective equipment	5
Working on moving or dangerous equipment	16
Improper starting or stopping	2

Excellent progress has been made in the control of electrical hazards and the good record has been attributed to the coöperation of manufacturers of electric equipment, governmental bodies, insurance companies, and others interested in the safe use of electricity. The National Electrical Code[1] and the National Electrical Safety Code[2] also play an important part in accident-prevention work.

Electric shocks due to the use of electric equipment occur without forewarning and are usually serious. The average individual thinks of the hazards of electric shock in terms of high voltage and does not always realize that it is primarily the current that kills and not the voltage. Consequently, persons who work around low-voltage equipment do not always have the same healthy respect for it that they do for high voltage. They do not realize that the governing factor is the relationship between the voltage one is in contact with and the resistance of the circuit of which

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[1] Developed under the sponsorship of the National Board of Fire Underwriters and approved as "American Standard" C1–1940. Also issued as "NBFU Pamphlet #70."

[2] Developed under the sponsorship of the National Bureau of Standards and approved as "American Standard" C-2. Also issued as Bureau Standards Handbooks 31, 32, 33, 34, 35.

his body is a part. If this resistance is low, the voltage may be low and still be sufficient to kill. Deaths from the ordinary 110-volt lighting circuit are frequent.

This chapter will deal primarily with voltages ordinarily used with shop lighting and power circuits (110-220-440 volts).

A person receives an electric shock whenever any part of his body becomes part of an electric circuit through which a sufficient current flows to cause discomfort or worse. Current flow slightly above that sufficient to cause discomfort causes involuntary contraction of the muscles, affects or stops the heart, stops breathing, or causes burns.

The course through the body may be local, as, for example, finger to finger, or hand to hand, or through the heart or central nerve system or other parts of the body, depending largely upon which part or parts of the body touch the live conductor and the ground. The shock may come from contact between a live part and ground or between two live parts at different polarity or phase.

The severity of injury from electric shock will be determined by the:

1. Amount of current that flows through the body.
2. Path the current takes through the body.
3. Length of time the victim is in the circuit.
4. Type of the electric energy in question.
5. Physical condition of the victim.

The amount of current that flows through the victim's body will depend upon:

1. The voltage of the circuit with which he is in contact.
2. The insulating qualities of the place in which he is located at the instant.
3. The resistance of his skin or clothing or both.
4. The area of contact with the live conductor.
5. The pressure of contact with the live conductor.

The current will take the path of least resistance through the body or over its surface or a combination of the two. Wet clothing may furnish a lower resistance path than that through the body, or part of the current may flow through the body and part over its surface.

Current of sufficiently high frequency heats but does not shock. This is taken advantage of in diathermy. Direct current is generally considered to carry less shock hazard for a given voltage than alternating current, but since D.C. arcs are more persistent than those from A.C., it is likely to burn more severely.

While physical condition is undoubtedly a factor at times, its importance is probably greatly overrated. Investigation of deaths from low voltages rarely justify the commonly heard comment, "His heart must have been bad."

Causes of injuries from low voltages

The causes of injuries from low voltages may be listed as follows:

1. Touching live parts.
2. Short circuit.
3. Accidental ground.
4. Overload.
5. Breaking connections.

Grounding all machine tools, casings, and structures

The frames or cases of all tools or structures in which electric devices or circuits are present should be substantially grounded.

The ground wire should be of low resistance and large enough to resist mechanical breakage and to carry off the heaviest current flow that might result from any insulation breakdown or other accident.

Particulars regarding such details as conductor sizes and nature of grounds are beyond the scope of this text. Reference should be made to the National Electrical Codes governing them.

Artificial respiration.

If the victim of electric shock has ceased breathing, it is essential that artificial respiration be applied immediately if his life is to be saved. He must first be removed from the live conductor, but his rescuer must not make the mistake of coming in contact with the live circuit himself.

For details of the proper procedure in rescuing and restoring the victim of electric shock, the reader is referred to the standard First Aid Manuals.[3]

Portable electric tools

Accidents and injuries resulting from the use of portable electric tools are much too prevalent. Many of these result from failure to ground the metal frame of the tool properly. Defective insulation permits the frame to be energized at, or near, line-potential, thus exposing the workmen to shock. Frequently, the injury

[3] These manuals may be obtained from the American Red Cross, Washington D. C. (or local offices), or the U. S. Bureau of Mines, Department of the Interior, Washington D. C.

from shock is minor compared to the injury resulting from a fall from a ladder or scaffold because of the shock.

The use of portable tools and extension lamps on steel structure and piping, in boilers and tanks, and on other jobs where the operator is in good contact with the ground is especially dangerous unless care and suitable equipment are used. To overcome the hazards, many modern plants are using a lower voltage (32 V) for extension lights and portable tools.

Regardless of where these tools are used, it is necessary to ground the frame of the tool by connecting a separate wire between the frame and a good ground.

A three-wire cord provides for carrying the two power wires and a grounding conductor. The grounding conductor may be connected to the ground by means of a clamp, or the three wires of the cord may be connected to a three-prong plug or contactor. The use of a three-prong plug requires a special wiring system and ground, as well as receptacles to accommodate the plugs. In the latter system, it is essential that the responsibility of connecting the wire be given to qualified people, since the ordinary workmen may fail to connect the proper wire to the ground. It is thus possible to reverse the grounding conductor of a three-wire cord whereby a live wire is used as a grounding conductor, with the result that the frame of the appliance becomes energized.

Because of the frequent hard usage and bad handling of portable equipment, frequent insulation-resistance tests may be necessary. The cords should be insulated with a high-grade rubber. Portable lamp holders and guards should be made of insulating materials.

Simple rules to follow

1. Do not guess about whether a circuit is alive or not. Consider every one alive until proved otherwise.
2. Use proper instruments for testing circuits.
3. Never touch any wire of a circuit unless you know that it is dead.
4. Use safety equipment when necessary, as rubber gloves, rubber mats, fuse tongs, insulated tools, and the like.
5. Lock open main switches and place tags before working on power circuits so that no one else may close them while you are working. Before closing a switch, make certain other workmen are clear of circuits.
6. Use danger signs and rope off dangerous areas.
7. In installing temporary electric wiring or apparatus, make every job safe.

8. Observe strictly the applicable rules of the National Electrical Safety Code.

9. Allow only qualified men to work on electric apparatus.

10. Arrange for proper maintenance of equipment, leads, and wires with careful follow-up to see that insulation is in proper condition.

11. Never bridge a fuse with wire or other metal.

12. Don't allow men to work on live circuits alone.

13. Don't test power lines with lamps to determine whether they are alive. A 110-V test lamp placed across a 440-V line will blow up. Voltage testers are available for testing.

14. Have periodic electrical inspections made by men qualified by experience and training to do such work.

WHAT THE INSPECTOR SHOULD LOOK FOR

Equipment and Hazard	*Correct Condition*
Sockets on extension cords or drop cords. Brass shells become "live" readily through moisture or conducting dust and dirt, or through wear or hard usage. The mechanism of key sockets may fail. Sufficient moisture or conducting dust may allow a shock to be received from even a key type weatherproof socket.	Use only insulated combination socket and handle with no live parts exposed.
Cords (extension). Insulation fails, metal lamp guards and metal cases become live through lack of insulation, moisture, or dirt, key sockets fail, plugs break or the parts loosen. Those used on portable power tools are subject to harder use and more often exposed to oil and grease.	Use heavy, live rubber cord, plugs of the moulded, nonbreakable type. Good practice requires that wall receptacles be provided for all extension cord use. Avoid unnecessary wear and abuse.
Electric wiring. Loose or improperly insulated or inadequately spaced wires may cause fires. Contact even with covered wires may result in shocks. Improperly placed wiring may be damaged.	Install all wiring in substantial and permanent manner when run, if possible; "temporary" wiring tends to become permanent. Properly knob, space, insulate, and secure open wiring. Do not run wiring where it may receive mechanical injury. Allow no cords, pendants or other conductors to be wrapped around or be in contact with water pipes, steel columns, or other metal parts. Use only rigid conduit in damp basements or similarly wet locations. Wiring for such incidental services as electric irons, clocks, etc. should not be substandard.
Fuses. Often bridged to permit overloads.	Bridging not permissible, mounting in boxes under lock and key sometimes advisable. Bridging usually evidence of overloaded circuit. Fuses should be on load side of switches and of correct rating for load.

Switchboards. Shocks from exposed live parts, flashes from the operation of air-break switches or circuit breakers.	Guard live parts, fence off space back of all boards, provide insulating mats. "Dead front" boards preferable.
Switches. Shocks from accidental contact or burns and shocks from operation under load.	Use only safety type of switches. Mount them so that blades are dead when switch is open.
Resistances, rheostats, controllers, etc. Burns from resistance grids, shocks from live parts.	Enclosure of live parts with operating handle external.
Treatment of victim of shock. Failure to do the right thing may mean death to the victim.	At least key men in every group should be trained in prone pressure resuscitation. All safety inspectors should be so trained and be competent to train others.

Electricity's "safety valves"

Protective devices used on electric circuits, such as fused switches and air-current breaks, are too often neglected in the plant safety program. Serious accidents due to the misapplication and incorrect operation of low-voltage fused switches have directed the attention of manufacturers and safety men to the removal of these hazards.

One of the first items to be considered is that in many cases the growth in current-generating capacity of the power system feeding the industrial plant has increased the amount of short-circuit current which must be interrupted when faults occur. The capacity of the protective devices, high enough when the system was installed, may be quite inadequate for later needs.

In many instances, fused switches or obsolete circuit breakers which were installed when the factory was built are still in service. Undoubtedly, these were the best available at the time; but, as in everything else, constant improvements have been made during the past few years. The safest protective devices of ten or fifteen years ago may now provide insufficient protection. They may in many instances be incapable of safely opening and closing the electric circuits and of interrupting present short-circuit currents. Consideration should be given to replacing them with devices that will give necessary protection for modern industrial loads.

Most persons realize that hazards exist when they see such signs as *Danger—Hands Off; Do Not Operate,* and other warnings. These, of course, are not substitutes for physical protection, and warnings are often disregarded.

How often do safety men, when making a plant inspection, check up on the switch and circuit breaker boxes to see whether

or not the fused switches and circuit breakers have the proper load and interrupting capacity and are kept free from foreign material? Switches that are capable of handling only their normal current capacity are likely to flash over between phases when called on to interrupt currents beyond their capacity. Even the stalled rotor current of a motor may be far in excess of the normal interrupting rating of such a switch.

If the switch is incapable of interrupting the stalled rotor current, an arc will be maintained and may cause phase-to-phase flashover and severe short circuit. When this happens, it may blow open the box cover and the flash may burn the person who has operated the switch. If the operator closes the switch and the motor stalls, the perfectly natural reaction is to open it immediately. If the switch is not capable of breaking the stalled rotor current, the operator may receive electrical burns from the resulting flash.

The following example will illustrate how accidents may occur. A worker repacking an air compressor had opened the contactor in the motor circuit and the motor disconnecting switch before starting to work. After the packing was completed, he closed them both. The motor stalled and he pulled the switch instead of tripping the contactor. The result was a flash-over in the switch box. The front of the box was blown open and the man was seriously burned.

Of course, the worker should not have pulled the disconnecting switch, but mechanical equipment should be arranged to lessen the possibility of accidents resulting from such human errors. Incorrect operation may occur in spite of constant training and reminding.

A further hazard arises from the limited current-interrupting capacity of fuses. In many instances, the short-circuit current available is in excess of the interrupting capacity of any National Electrical Code fuse on the market. The dependability of a fuse within its capacity is unquestioned, yet its limitations must be recognized and the fuse applied accordingly.

Specific types of air-circuit breakers also have limitations in interrupting rating, but a very large range of ratings is available in standard types (rated interrupting current from 5,000 to 80,000 amperes). The advantage of the breaker over the fused switch is that the breaker has no limitation as far as breaking stalled rotor current is concerned, or, in fact, any current within its interrupting rating. Once the proper breaker for the circuit is installed, there is no danger of damaging it or injuring the operator, if the operator should trip it under heavy load or short circuit.

In the fused-switch combination, the fuse is the part that must automatically interrupt overloads or short circuits. The switch cannot; it serves mostly to open or close the circuit under normal load conditions. In some cases, it is capable of interrupting stalled rotor current. In the circuit breaker, on the other hand, the interrupting element is self-contained and is always in action when the breaker is opened, either automatically on overcurrent, or by the operator.

The breaker trips free from the operating handle and cannot be held closed when a short circuit or overload exists. It should be enclosed so that the operator is not exposed to live parts.

Thus it would seem necessary to study our electrical installations and, if they are found inadequate for present requirements, to replace the weak links with higher duty devices. Circuit breakers are more efficient than the fused switch and provide more effective protection against personal injury.

While this discussion is concerned chiefly with low-voltage circuits, it might be well to mention the importance of checking the adequacy of oil-circuit breakers installed on the higher voltage circuits. Do they have sufficient interrupting capacity? No doubt, they were of high enough duty when installed; but has increased system capacity since their installation made them incapable of opening possible short currents? Modernization or replacement of old, overstressed oil-circuit breakers may prevent a fatal accident.

Where the higher voltages are used, steel-enclosed equipments for controlling feeders, motors, and transformers are desirable. They contain the circuit breakers and associated equipment which are thus safely removed from accidental contact. The National Electrical Code permits such enclosed equipments up to 15,000 volts to be installed in working areas.

REVIEW

1. Name five conditions which may favor the flow of electric current through the body.

2. What are the advantages of grounding electrical equipment?

3. Describe a three-wire cord, receptacle ground connection.

4. Why is it unsafe to replace fuses with other conducting metals?

5. Before a workman starts work on electrical equipment, what is his first step?

6. Mention five safety rules to follow in connection with electrical equipment.

CHAPTER XVII

Fundamentals of Machine Guarding

Prior to the organized safety movement in industry, it was the common practice to operate transmission machinery (gears, belts, pulleys, shafting, and the like) wholly unguarded. Since the countersunk set screw for use on line shafting had not been developed, shafting bristled with projecting set screws. Few, if any, machines were designed with any thought of worker safety, nor were they equipped with anything in the nature of safety devices or safeguards. Little attention was paid to such matters as the safe placing of machines, the provision of emergency stops, or the safe arrangement of machine controls.

First, emphasis was placed on the guarding of transmission machinery. The frequent deaths of workers snatched up by projecting set screws and whirled about the shafting or caught in meshing gears focused attention on these hazards. Many states adopted legislation requiring the safeguarding of dangerous machinery and set up factory-inspection systems to secure compliance. Methods of guarding were worked out, suitable materials were developed for the purpose, means of eliminating projections from shafting and other rotating parts were found. Standards for machine guarding gradually crystallized out of this effort, and these standards, enlarged and refined over the years, are now largely embodied in the "American Standards" safety code for the guarding of transmission machinery under the title "Safety Code for Mechanical Power Transmission Apparatus." The function of the American Standards Association in the development of safety codes is discussed in the chapter, "Safety and Health Standards and Rules."

The provisions of the "American Standards" safety code for guarding of transmission apparatus have been adopted or followed quite closely by most of the industrial states and have been widely accepted by industry. Plants whose safety performance is representative of good or best engineering practices comply with the provisions of this code as a matter of course; but in many industrial

establishments, chiefly smaller plants, machine guarding is still far from adequate. In such establishments projecting set screws are still to be found, gears are often unenclosed, hazardous belts are still unguarded, and other essentials of machinery safeguarding are often unsatisfactory.

Injuries caused by machines are usually serious. Many amputations have resulted from injuries due to transmission machinery and metal-working machines, while woodworking machines have been the cause of many missing fingers. The screw conveyor established a particularly bad record until it became generally recognized that complete enclosure is the only acceptable method of guarding this equipment. Each type of machine contributed its quota of injuries to the mounting toll that inspired the nation-wide effort at prevention which has accomplished so much yet has so much more to do.

Progress in guarding most of the commonly used machines has been relatively slow, however, because their guarding has had to await the development of practical safeguards and their widespread acceptance and use. Fairly satisfactory safeguarding standards have been developed and approved as "American Standard" for most machines, but even here there is need for improvement in detail and in the development of definite specifications for the guards themselves. One of the chief needs is for a change in point of view in two vitally important respects. First, the great importance of machinery safeguarding must be much more universally accepted. Second, the present attitude of "afterthought" guarding must be changed to one of "forethought" guarding; that is, the generally prevailing practice of buying a machine and then guarding it after installation must be changed so that safety is designed and built into every machine. Only by this means can really effective safeguarding be achieved for many of our most hazardous machines, particularly those commonly used in wood- and metal-working.

Frequency of machinery injuries

There appears to be a general underappreciation of both the numerical and the actual importance of machinery-produced injuries. The commonly heard statement that "only from 10 to 15 per cent of injuries are due to mechanical hazards" may, on superficial analysis, seem to be borne out by summaries from the records of various state compensation authorities. However, if the totals for any industrial state are analyzed on an industry basis, a very different picture emerges. Table 11, published by the New York State Department of Labor, illustrates this.

TABLE 11

NUMBER AND PERCENTAGE OF COMPENSATED INDUSTRIAL INJURIES CAUSED BY MECHANICAL APPARATUS, BY INDUSTRY, NEW YORK, 1940

Industry	Number of compensated injuries	Per cent	Injuries due to mechanical causes	
			Number	Per cent
All industries	79,280	100.	9,145	8.7
Manufacturing industry	24,012	30.	6,225	25.9
Service industry	18,520	23.	866	5.6
Construction industry	13,796	17.	1,061	7.6
Transportation and public utilities	12,549	16.	311	2.5
Trade	9,042	12.	569	6.3
Others	1,361	2.	113	0.8

For New York state as a whole, only 8.7 per cent of compensated injuries are charged to mechanical causes; but for the manufacturing industries the proportion rises to 25.9 per cent. And 30 per cent of the total of compensated injuries in the state occurred in the manufacturing industries (more than in any other industry). In the manufacturing industries, which is the largest industrial group, mechanical equipment is thus shown to be a major injury producer on a state-wide basis. The analysis of the accident records of the larger manufacturing firms will frequently show a low proportion of machinery-produced injuries, again seemingly bearing out the oft-quoted statement that only 15 per cent of all injuries are caused by machines. But such firms have gone much further in guarding their machinery than has the average plant, and their experience should be quoted as representing good or best practices, not average conditions.

Seriousness of machinery injuries

One measure of the severity of injuries is the percentage of them causing permanent-partial disabilities, that is, the loss of a member or loss of use of a part of the body. The proportion of permanent-partial disabilities is high for machinery-produced injuries, as Table 12 shows.

For all industries combined 28.6 per cent of the compensated injuries caused permanent disabilities, but for the manufacturing industries this proportion rose to 32 per cent. A breakdown of the manufacturing industries, if available, would show that those

industries using large numbers of hazardous point-of-operation machines, such as wood and metal working, have still higher rates of permanent partial injuries. In dealing with New York injury statistics, it should be borne in mind that only those injuries causing a time loss of seven days or more are compensable; thus the seemingly large percentage of permanent partial disabilities is accounted for.

TABLE 12
NUMBER AND DISABILITY DISTRIBUTION OF COMPENSATED INDUSTRIAL INJURIES, BY INDUSTRY, NEW YORK, 1940

Industry	Total Number of Cases	Kind of Disability: Death and permanent total, Number	Death and permanent total, Per cent	Permanent partial, Number	Permanent partial, Per cent	Temporary, Number	Temporary, Per cent
Total—all industries....	79,280	764	1.0	22,670	28.6	55,846	70.4
Manufacturing..........	24,012	153	0.6	7,676	32.0	16,183	67.4
Service industries........	18,520	190	1.0	4,524	24.4	13,806	74.6
Construction............	13,796	183	1.3	4,474	32.4	9,139	66.3
Transportation and public utilities..............	12,549	146	1.2	3,391	27.0	9,012	71.8
Trade..................	9,042	72	0.8	2,235	24.7	6,735	74.5
Other industries.........	1,361	20	1.5	370	27.2	971	71.3

Further evidence of the severity of injuries caused by machines is obtained by examination of injury data classified according to cause and severity of injuries. Table 13 illustrates this point.

This table shows that elevators, hoists, and conveyors (a form of mechanical equipment) caused the second highest percentage of fatal injuries, being exceeded only by "other vehicles." Injuries charged to mechanical apparatus as represented by "machinery, prime movers, and so on" show the highest proportion of permanent partial disabilities, 54 per cent of all such injuries involving loss of a member or loss of use of a member. The severity of the injuries resulting from the operation of mechanical apparatus is obviously a factor of major importance.

It should not be necessary to dwell on the seriousness to a wage earner of an amputation or the loss of use of a member. Workmen depend on the continued effectiveness of their hands,

feet, eyes, and so on, for their livelihood. The usual result of a permanent disabling injury is to condemn the victim and his dependents to a scale of living so much lower as to sacrifice most

TABLE 13

NUMBER AND DISABILITY DISTRIBUTION OF COMPENSATED INJURIES, BY CAUSE OF INJURY, NEW YORK, 1940

Causes of Accidents	Total Number of Cases	Kind of Disability					
		Death and permanent total		Permanent Partial		Temporary	
		Number	Per cent	Number	Per cent	Number	Per cent
Total	79,280	765	1.0	22,670	28.6	55,846	70.4
Handling objects and tools	29,921	93	0.3	7,456	24.9	22,372	74.8
Handling objects	25,201	81	0.3	5,504	21.9	19,616	77.8
Using hand tools	4,720	12	0.3	1,952	41.3	2,756	58.4
Falls of workers	17,973	165	0.9	4,468	24.9	13,340	74.2
Falls to a different level	7,707	134	1.8	2,145	27.8	5,428	70.4
Falls on the same level	10,266	31	0.3	2,323	22.6	7,912	77.1
Mechanical apparatus	9,145	84	0.9	4,871	53.3	4,190	45.8
Machinery, prime movers, etc	7,598	30	0.4	4,104	54.0	3,464	45.6
Elevators, hoists and conveyors	1,547	54	3.5	767	49.6	726	46.9
Vehicles	5,922	191	3.2	1,841	31.1	3,890	65.7
Motor vehicles	4,901	150	3.0	1,469	30.0	3,282	67.0
All other vehicles	1,021	41	4.0	372	36.4	608	59.6
Dangerous and harmful substances and occupational activity	5,484	129	2.4	721	13.1	4,634	84.5
Electricity, explosion, heat, etc	2,737	68	2.5	521	19.0	2,148	78.5
Harmful substances	2,747	61	2.2	200	7.3	2,486	90.5
Accidental injuries	972	15	1.6	118	12.1	839	86.3
Occupational diseases	1,775	46	2.6	82	4.6	1,647	92.8
Stepping on and striking objects	3,853	15	0.4	826	21.4	3,012	78.2
Falling objects	3,483	42	1.2	1,316	37.8	2,125	61.0
Other indefinite	3,499	45	1.3	1,171	33.5	2,283	65.2

of life's advantages and hopes. The compensation payments at best do little more than cushion the blow. And the war has taught us that our workers are a vital asset to our country. Preserving this asset is not only the essence of humaneness, it is a matter of good common sense.

Harm of the 15 per cent to 85 per cent ratio fallacy

Factory inspectors charged with the duty of securing the adequate safeguarding of machinery are almost continuously opposed by the argument that since only 15 per cent of injuries are from mechanical sources, little can be gained by such guarding and the required expenditure would better be applied to the prevention of the 85 per cent of injuries due to other causes. At times this argument may be merely an excuse to avoid the expenditure of money for guarding; but in most cases it is undoubtedly an honest opinion due to acceptance of the superficial and misleading statement of the 15 to 85 per cent ratio. As already stated, such a ratio should not be taken as a measure of the relative importance of machinery safeguarding. On the contrary, there are many reasons why machine guarding should be the first prerequisite of any well-rounded safety program. Also, as previously indicated, the percentage of permanent partial disabilities from machines is extremely high. Serious injuries involve high cost and large time losses. Is it not logical, therefore, to try to eliminate those injuries causing high cost and large time losses?

Perhaps the most important reason for doing machine guarding before undertaking other safety activities is the psychological effect on the workmen. Guarding is a positive and visual proof of the sincerity of the management's interest in safety. Guards cost money and their erection is proof that the management is willing to spend money in its safety effort.

Machine guarding foundational

Machine guarding should be considered as the foundation on which all future safety activities are based. Management cannot expect the men in the shop to work safely, to acquire safe habits, and to be interested in the safety of their co-workers unless they are given a safe place in which to work. A safe environment created, partially at least, by adequate safeguarding of machines is in itself an incentive for a worker to develop safe working habits.

Machine guarding should not only be adequate to protect from the hazard of the machine, it must itself represent a high standard of quality and workmanship. Poorly designed and poorly constructed guards give the lie to any profession of an interest in safety that the management might make. A guard has but one purpose—to protect someone from contact with a point of danger, and any guard that does not do this fails its purpose. In fact, a poor guard may be worse than no guard at all. It sets up a sense of false security and the workman depends upon a guard rather

than trying to protect himself against a hazard that he knows exists. Guards can be made attractive as well as useful. Many companies have adopted a policy of painting all guards a distinct color, usually green. This is an excellent idea; it not only makes guards attractive, but it indicates instantly which machine parts are guards.

Machine builders making safer machines

Machine builders in general have incorporated into their current models many safeguards that a few years ago were entirely lacking. All modern engine lathes have the back gears built into a permanent housing with the lever for changing speeds as the only exposed part of the gear train. Belts, which are sometimes a part of the machine itself, are often so placed within the fully enclosed frame of the machine as to eliminate the necessity for a separate belt guard. Many machines have been redesigned to eliminate shearing or crushing hazards; for example, the ordinary reciprocating boiler feed pump. Older models lacked finger clearance between the cross head and the packing glands, and incautious attendants often received crushed hands or fingers in wiping or making adjustments. There are other examples of excellent safeguarding by machine manufacturers. Modern laundry machinery furnishes one. Bakery machinery another. The ordinary abrasive wheel stand as manufactured complete is well guarded, but this is often not true of those assembled by jobbers. Modern meat grinders have been designed with feed hoppers of a depth greater than finger length and a throat too small to admit one's hand.

However, comparatively little progress has been made compared to the tremendous possibilities that exist for building user safety into the machines instead of adding it later in the form of guards. Unfortunately, this is chiefly true of the common highly hazardous wood- and metal-working machines. Machine tool builders have been slow to accept the fact that the guards on the machine are actually a part of the machine, chiefly because of lack of consumer demand for fully guarded machines. Most machine buyers purchase on a price basis. The purchasing agent, trained to buy satisfactory goods at the lowest possible price and not being a safety engineer, does not specify that the machine be equipped with guards or that guards be built in. The seller of a machine who includes in his selling price the cost of guards is at a disadvantage when competing with a seller who is not interested in providing guards or built-in safety. This is a condition that can be corrected only by management's willingness to pay whatever

reasonable extra price may be necessary to secure a well-guarded machine, plus close coöperation between the safety department and the purchasing agent.

Another condition that seriously hinders the development of fully guarded standard models of machines is the diversity of state laws and regulations governing such equipment. Specifications for guarding are not uniform and guards acceptable in one state may not be acceptable in a neighboring state. This condition has been, and unless corrected will continue to be, a serious obstacle to the development of universal guards; but some progress is being made in overcoming this handicap through standardization of safety codes. Many states have adopted verbatim various of the "American Standard" safety codes; others have used these codes as the basis of their state codes with some slight difference in minor details. However, many conflicts still exist between the standards applied by the individual states. A program aimed at the correction of this condition has been initiated by the International Association of Governmental Labor Officials, but satisfactory results are difficult to obtain because of the volume of work required in analyzing the many safety requirements and in resolving the conflicts among the various states.

Homemade guards

In the field of home-made guards—that is, guards built in the shop where used, or guards built by a company specializing in guard construction—knowledge and skill are especially important. Each guard is made-to-order, each must be specially designed, and each individual machine presents its own problem. State codes give the broad, overall requirements as to performance or construction, but the effectiveness of the guard is still dependent upon the skill of the designer and the builder to design and construct a guard that is adequate for the purpose, is sturdy enough to withstand hard service, and does not in itself create a hazard.

Primarily, guards are intended to protect the machine operator or the casual passer-by, and this is the aim of the designer. But in guard design other important features should not be overlooked. For example, guards should be so designed as to offer maximum protection to the repair man and the oiler. Guards are sometimes interlocked with the driving mechanism in such a way that the machine cannot be operated unless the guard is in place. Automatic machines, such as those used in the manufacture of small metal products as metal boxes for typewriter ribbons, lend themselves to interlocking guards. Many of these guards are very

ingenious and their designs offer a fertile field for specialized safety work. This principle of interlocking the guard with the machine control to prevent operation unless the guard is in place could and should be widely applied, and it is so applied in certain plants whose managements are highly safety-minded.

Wherever possible (and it is rarely impossible), provision should be made for oiling machines without removing the guard. A simple way to do this is to locate the oil reservoir outside the guard with the oil line leading to the point of lubrication. On machines requiring grease lubrication, pressure fittings are commonly used. Here, too, long tubed fittings can be used with the fitting for the grease gun located away from the moving part and outside the guard.

Provision should be made for cleaning and adjusting machine parts enclosed by guards. Ease of cleaning or adjusting can be facilitated by making panels in the guards which can be removed without removing the entire guard. These sections should be hinged so that they can easily be opened but are not in danger of being misplaced. They should preferably be interlocked with the controls; but if not, they should at least be "in the way" unless closed. Each guard is an individual problem and no set rule will apply to all possible conditions.

Finally, guards are not a makeshift and should not be considered as such. They are designed and built for but one purpose —to protect against a hazard which might cause an injury; and no trouble or expense should be spared in making guards the best that can be made. If the abilities of competent designers are brought to bear on the problems of safeguarding machinery, improvement will be rapid. Anyone who compares the excellence of modern machine design, from the standpoint of effective machine functioning, with that of machine safety, will be impressed by the fact that safety is often treated as though it were of secondary importance. The safety of those who work with our machines must receive more consideration from those who build them.

REVIEW

1. Why was machine guarding one of the first activities of the organized safety movement?

2. To what extent is it true that "only from 10 to 15 per cent of injuries are due to mechanical hazards"?

3. Which cause of injury is responsible for the largest percentage of permanent partial injuries?

4. For what reasons is machine guarding the first prerequisite of a well-rounded safety program?

5. State safety regulations offer an obstacle to the development of universal guarding standards. Why?

6. Why should worker safety be a major part of machine design?

7. Why should guards be attractively finished and kept in first-class condition and appearance?

8. Why should safety-minded employers favor the development of adequate guarding requirements for all industry?

CHAPTER XVIII

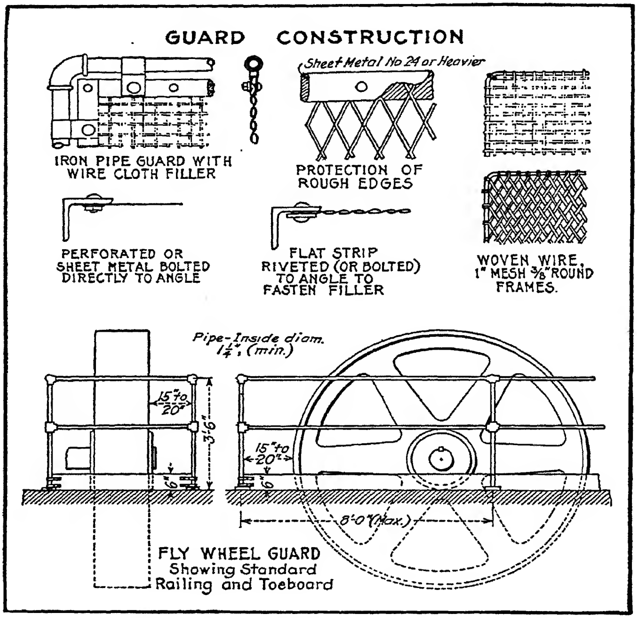
Guarding of Transmission Machinery

The safeguarding of machinery falls into two main classifications: the guarding of mechanical power transmission apparatus and the guarding of the point of operation on the driven machine. This chapter will discuss the guarding of mechanical power transmission apparatus. The guarding of the point of operation of the driven machine will be discussed in later chapters.

Mechanical power transmission apparatus is usually defined to mean and include all moving parts of equipment used in the mechanical transmission of power, including prime movers, intermediate equipment, and driven machines, and excluding the point of operation. Transmission apparatus includes belts, pulleys, gears, shafting, starting and stopping devices, clutches, couplings, prime movers, and other equipment used for transmitting power. It is apparent that the guarding of transmission equipment is in itself a far-reaching subject, its full details being far beyond the scope of a text such as this. This chapter will present the broad principles of guarding of power transmission apparatus and will point out certain other important factors to be considered in machine guarding; but it will not attempt to fill in the details that rightfully are within the province of a safety code. The "American Standard" Safety Code for Mechanical Power Transmission Apparatus has received national acceptance and is unquestionably the best safety code on the subject. Many state safety codes are based on it, and some states have adopted it without change. It should be used for detailed information as to what equipment should be guarded and how guards should be constructed. Other excellent references for machine guarding are the "Handbook of Industrial Safety Standards" published by the National Conservation Bureau, an identically titled publication of the American Mutual Liability Insurance Company, and the Safe Practices Pamphlets "Mechanical Power Transmission Apparatus" published by the National Safety Council.

Guards should always be substantially constructed and firmly secured. Many guards are located along aisles used by industrial trucks and are subject to hard usage. Light, flimsy construction

will not stand up under this or other hard service. The materials of construction should never be less than the minimum specification of the American Standard code. It should be borne in mind, however, that in using any safety code the specifications represent minimum standards. Local conditions or expected hard usage will frequently necessitate the use of much heavier material.



Construction details for guarding of transmission apparatus.*

Metal is the only satisfactory material for construction of guards for mechanical power transmission apparatus. When used in proper sizes, it has the durability and strength to withstand ordinary wear, does not in itself create a fire hazard, is easily cleaned and repaired, and occupies a minimum of space. The choice of what metal section to use is largely a matter of preference or convenience. Some safety engineers prefer angle iron for the

* This illustration and the four immediately following are taken from the American Standard Safety Code for Mechanical Power Transmission Apparatus B15-1927, published by The American Society of Mechanical Engineers.

framework, others prefer pipe. Likewise, some prefer perforated metal as the filler, and others prefer sheet metal, woven wire, or expanded metal. Some of the factors to consider in selecting the filler are: the necessity of seeing the equipment guarded, the possibility of the collection of inflammable dust such as fly or lint on the guard, the size of the perforation or opening in the material, and the presence of corrosive chemicals or fumes.

Wood is sometimes used for transmission machine guarding, particularly in woodworking plants, in which case there may be some justification for it's use. However, wooden guards are short-lived, lack strength, contribute to the fire hazard, and are difficult to remove and replace without injury. Some safety engineers prefer wood because it is less subject to corrosion than metal. This, in itself, is a poor argument against metal guards, because fumes or vapors that will corrode metal are likewise harmful to the worker and probably indicate the necessity of control to protect his health. Corrosive resistant finishes may also be applied to metal to diminish or eliminate the effect of corrosion.

In the construction of guards, care must be exercised that the guards themselves do not create a hazard. Sharp edges, exposed bolts, and unfinished surfaces offer possibilities for cuts and lacerations. All edges should be rolled or bolted within the angle iron of the frame, and rounded corners are desirable.

The knowledge of how to design and construct guards is only a part of the information necessary to prevent injuries due to mechanical power transmission apparatus. Some knowledge of transmission equipment, its dangers and its limitations, is also necessary. There follows a discussion of some of the things that a safety engineer should know about power transmission apparatus. This discussion is not intended to be complete or to indicate all the factors that make transmission apparatus dangerous; it is intended only to highlight some of the most important considerations. Additional detailed information may be secured from the publications mentioned at the beginning of this chapter.

Guarding of belts

The selection of the proper belt for the service for which it is intended should be given consideration before provision is made for guarding it. A belt that will not slip under load, one that needs a minimum of attention and is not easily broken, is the first prerequisite of safety from the belt. In the choice of belts, consideration should first be given to the condition under which it is to be used. For most general purposes leather is satisfactory; for locations where there is an excess of moisture such as steam, good

practice may dictate that a rubber composition or fabric belt be used. Expert advice should be sought from the manufacturer or dealer as to which belt should be used under given conditions.

In determining the size of the belt needed, the load that the belt is to pull and the speed at which it is to operate must be considered. The higher the speed of the belt, the stronger the belt must be to overcome the stresses due to speed alone. Each size belt has its own most efficient speed where it will transmit the maximum power without undue depreciation, and this speed should obtain where possible. Belts are usually sold on a guaranteed strength basis, and it should be borne in mind that leather, rubber, and fabric belts have each a different tensile strength. Information on the strength of belts is available from various technical handbooks or it may be secured from the belt manufacturer. A belt should never be installed unless its ability to do the work intended of it has been ascertained.

The type of belt fastener used is of great importance from a safety standpoint. Probably the safest method of fastening the belt is to make the belt endless, that is, by beveling the ends to be joined and glueing them together. This operation requires considerable skill and should only be done by a skilled workman. Unless the joint is accurately made the belt will not run true, and if insecurely made it will pull apart. Rawhide or leather fasteners are preferable to metal ones. Catgut, similar to that used in tennis racquets, is also an excellent belt lacer. Various kinds of metallic lacers are available and are satisfactory for joining the belt ends, but most of them offer very definite accident hazards, especially if the belt is unguarded. Some of these metallic lacers employ wire staples; others are of the solid metal type operating through a hinged joint; still others employ a metal plate riveted to both ends of the belt, the plate acting as a butt strap of a riveted joint. Metallic lacers all have one disadvantage: as the lacer wears, the ends of the wire or the edges of the rivets become exposed and can cause serious injury if they come in contact with the hands or other parts of the body. A good rule to follow is to permit no metallic belt fastener on belts shifted by hand or belts left unguarded where contact with them is possible.

The direction of the run of the belt also has a bearing on the hazards. A horizontal belt is more hazardous than an inclined or vertical belt, and, other things being equal, an inclined belt offers more possibility for injury than a vertical one.

There are two accepted methods of guarding belts—by a complete enclosure, and by a standard railing. Enclosure guards are used for most belt guarding, the exceptions being large belts from

prime movers or belts located in unused places such as a transmission basement. Enclosure guards are usually carried to a height of seven feet from the floor or, in the case of horizontal belts, to the top run of the belt. Standard railings are customarily 42 inches in height with a center midrail. As previously stated, it is not the intent of this text to go into construction details, such details being available from safety codes covering transmission apparatus.

Guarding of pulleys

Guards for belts are usually constructed to guard the pulley also, but under some conditions it may be desirable to guard only the pulley, the belt not needing guarding. This is particularly true of small belts and belts used in conjunction with cone pulleys. Since the contour of the face of the pulley has a direct bearing on the degree of accident hazard of the pulley, this should be considered in determining the necessity to guard the pulley. A pulley with a V-face, for use with a V-belt, is more dangerous than a flat or crown pulley. Likewise a U-faced pulley for use with a round belt may cause a more serious injury than does a flat or crown pulley of the same size. A flanged pulley, while not as hazardous as a V- or U-shaped pulley of approximately the same size, represents a greater hazard than does a flat- or crown-faced one. For large belts, the flanged pulley is considered to be far more hazardous than a flat pulley for the same size belt. Frequently small belts are used in conjunction with other than flat pulleys, and good practice dictates that the pulley be guarded, although the belt need not be guarded.

When separate pulley guards are used under conditions where the belt does not require guarding, the guard encloses the pulley so as to protect the run-in point of the belt. The guard should extend slightly higher than the top of the pulley, the belt running through a slot or narrow opening which would not permit the hand to be drawn into the nip-point. The same principle is applied to cone pulley belts, or tight-and-loose pulley combinations where a belt shifter is used. In this type of guard, care must be used that another pinch-point is not created between the belt and the guard which may be as bad as the one between the belt and the pulley.

In addition to enclosure guards for the pulley, certain other safety precautions should be observed regarding pulleys. These will be touched on briefly. In certain cases, the run-in point of the belt may be located more than 7 feet above the floor, offering little hazard; but there may be danger from the spokes of the

pulley. In such cases it is considered an acceptable practice to guard only the spokes. This is done by means of a disc of metal fastened to the spokes or the rim of the wheel with U-bolts, the nuts or other fastenings being on the unexposed side. This type of guard is frequently used on the flywheel of a punch press.

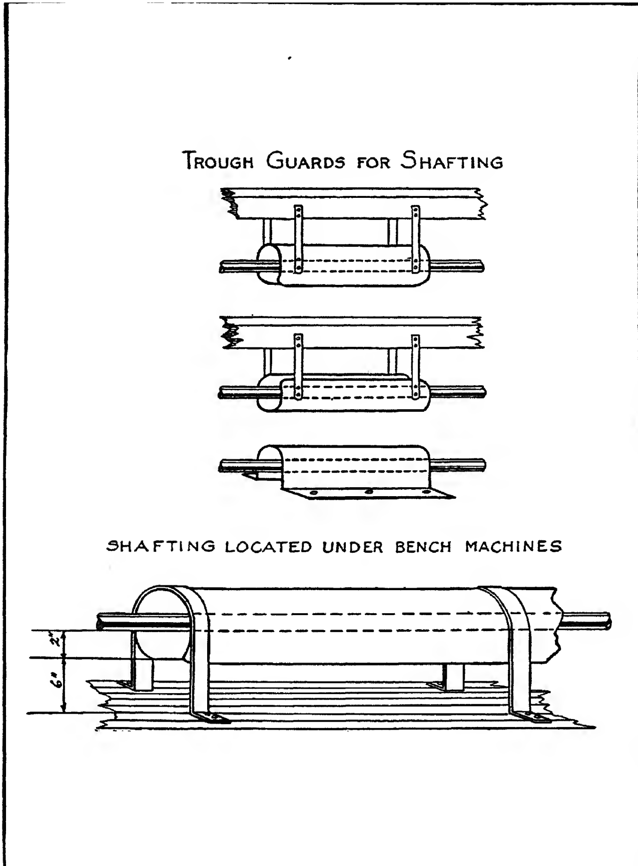
Where a pulley is located near a shaft hanger or bearing, a shield should be placed between the pulley and the bearing for protection of the oiler. A pulley should not be placed outside the hanger on the shaft end unless provision is made to keep it from falling if it should become loose on the shaft. Pulleys should be aligned properly on the shaft to prevent weaving of the shaft and also to prevent the belt from running off the pulley.

Cast pulleys should be inspected for cracks. This can be done by striking the pulley lightly with a hammer; a cracked pulley will give a different ring than a perfect one. The belt should always be removed when hammer-testing a pulley, as the belt causes a different ring. Split pulleys should be inspected to see that the holding bolts are tight. Proper inspection and maintenance of pulleys will discover and correct developing defects that eventually cause breakdowns or accidents, or both.

Guarding of shafting, couplings, keys, collars, and set-screws

The guarding of shafting and its appurtenances is an important phase of the guarding of mechanical power transmission apparatus. Shafting accidents are nearly always severe, often fatal, and are caused by the loose clothing of the workman being caught by the revolving shaft. Any roughness or projections of any sort, such as keys or set screws, increases the possibility of shaft accidents. The projecting set screw is particularly hazardous and should be replaced by the safety set screw. But even a perfectly smooth rapidly revolving shaft can grasp loose clothing and whirl the victim around the shaft. Shafting is usually located in out-of-the-way places, back of or underneath machines or overhead so that the repair man must work in close quarters or from a ladder. The fact that freedom of motion is usually lacking when persons are working near shafting increases the number and severity of shaft accidents. Another reason for the large number of shaft accidents is that shafting does not look dangerous. Many persons, therefore, fail to realize the danger and so do not take even ordinary precautions when working about it. And when loose clothing such as shirt sleeves, neckties, aprons, or long hair in the case of women employees, become entangled in the shaft, it is impossible for the individual to get loose.

Most safety codes specify that all shafting located less than 6 feet above the floor shall be guarded, except where located within the frame of the machine. Guarding is accomplished by covering

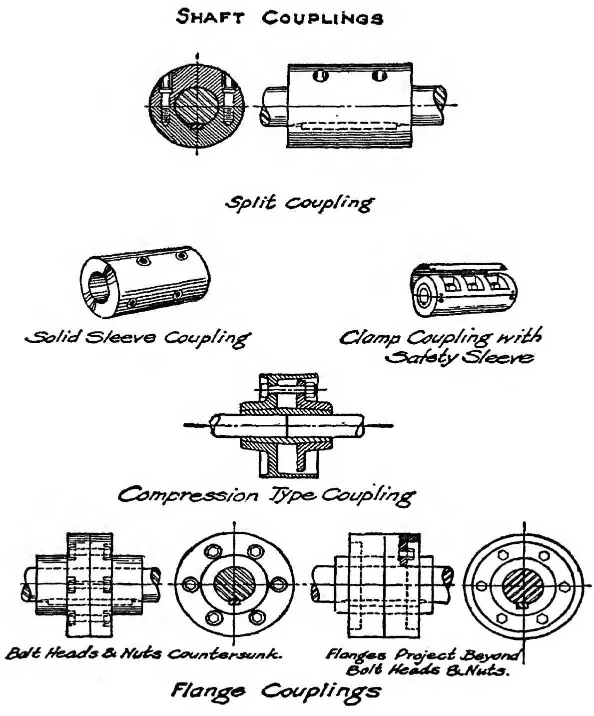


Methods of guarding shafting.*

the shaft with a stationary guard. This guard should be of sheet metal, entirely enclosing the shaft; or it may be in the shape of an

* See footnote, page 186.

inverted U open at the bottom. A standard railing is sometimes used, but this is not very desirable, as repair men or oilers may have to work from inside the guard. Shaft ends extending beyond the machine or hanger should be guarded in the same manner as the

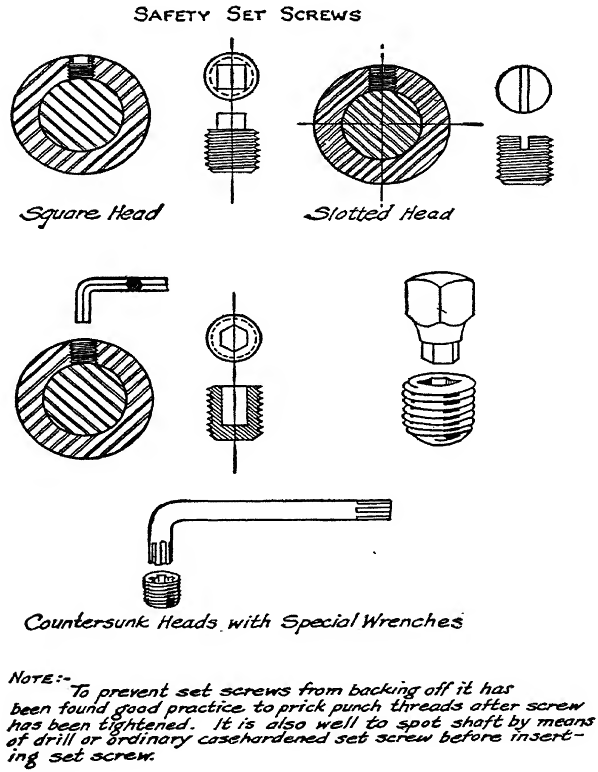


Safety couplings.*

shaft or cut off flush with the housing. Shafts under bench machines, such as sewing machines, should also be guarded. This is especially true where women are employed, as their loose clothing and long hair offer an especially severe hazard about revolving shafts.

* See footnote, page 186.

Shaft couplings offer the same type of hazard as does the shaft but to a greater degree. The periphery, being larger than the shaft, has a greater linear speed and does not present the unbroken



Safety set screws.*

surface that a shaft does. Safety type coupling should be used. This type of coupling is free from projection, the bolt heads and nuts being countersunk or protected by a flange. But even a safety coupling does not eliminate the danger of clothing being

* See footnote, page 186.

wrapped around the coupling; therefore, any coupling that presents a revolving surface, whether or not of the safety type, should be guarded. Guarding of shaft couplings is accomplished in the same way as shaft guarding, by a shield covering the coupling so that contact with it is impossible.

Keys, collars, and set screws, when used in conjunction with pulleys or shafting, increase the normal hazard of revolving equipment by their projection beyond the plane of the shaft or pulley. Projecting set screws, particularly, have so bad a record that most states specifically prohibit their use. Only safety set screws—the heads countersunk and not projecting beyond the periphery of the shaft or pulley—should ever be used. Keys should also be guarded to eliminate the projection.

Guarding of gears

While available data does not permit an accurate comparison of the relative hazard of the various component parts of power transmission machinery—gears, shafting, belts, clutches, and the like—it is certain that gears, along with projecting set screws, take their place at the top of the hazard list. Gear injuries, particularly those caused by large gears, are always serious. All gears, with the possible exception of those located entirely within the frame of the machine, should be guarded. This statement applies also to hand-operated gears. There is practically no such thing as guarding adequately "by position," for the records are full of instances of maintenance men, cleaners, painters, and so on, getting caught in gears quite out of reach of all ordinary work locations or activities. Complete enclosure, regardless of location, is the only really adequate safeguard, although band guards may be acceptable under some conditions. A band guard is a guard shaped to conform to the contours of the gear train and having flanges extending inward to at least the depth of the teeth. Some safety codes permit guards that cover the nip-point only, but this is definitely inadequate because it creates a pinch point between the gear and the guard and thus merely reduces the hazard instead of eliminating it. Railings should never be used for guarding gears.

On superficial consideration, chain drives might be thought comparable to belts. Actually they are much more hazardous and should be classed with gears. Where chain drives are located more than 7 feet above the floor, the guarding may be unnecessary if provision is made for protection for the oiler and repair man. Where chain drives are located over passageways or work places, provision should be made so that the chain, in case it breaks, will not fall and injure any person working or passing underneath.

An important advantage of complete dust- and oil-tight enclosure of gears and chains is that it greatly reduces wear and thus greatly increases the life of the equipment. Experience shows that such enclosures pay for themselves in this manner alone, to say nothing of the greater safety they furnish.

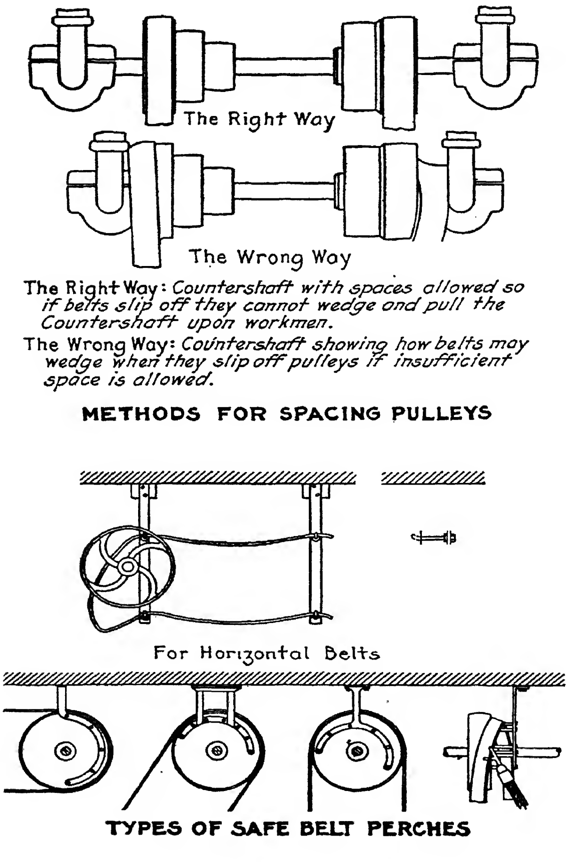
Starting and stopping devices

Since starting and stopping devices are used for connecting and disconnecting power transmitted by mechanical power transmission apparatus, the safety features of such equipment are considered a part of the guarding of transmission apparatus. Methods used for power control include motor switches for individual electric motor-driven machines, clutches for connecting and disconnecting power transmitted by shafting, and belt shifters, belt shippers, poles and perches for shipping belts to and from pulleys.

Motor switches should be located as near to the normal working position of the operator as possible so that they can be reached easily in case of an emergency. On machine tools operated by one person this can usually be accomplished, but for large machines such as are used in the steel industry or in paper making, a single control will obviously be distant from some parts of the machine. In such cases, sufficient emergency stop stations should be provided to permit the machine to be shut down from any working station. Such emergency stop locations should be well marked by signs or lights. If electrically operated, they should operate on a normally closed circuit so that the circuit cannot be broken without stopping the machine. The entire crew should be trained in their use and they should be used occasionally for routine shutting down of the machine. Motor switches should be of the enclosed, arcless type, operated by push buttons or a handle or lever located outside the switch box.

Belt shifters should be provided for shifting belts from a loose to a tight pulley, or for shifting belts on a cone pulley. Shifting belts by hand is unduly hazardous and should not be regarded as an acceptable practice. Belt shifters should be positive in action and should be provided with a locking device so as to keep the shifter in position. Shifter handles should be so located that they can be reached from the normal working position. They should also be located so that the shifter handle will not be accidentally struck by the operator or by other persons or trucks in aisles and passageways. The handle should always be so hung that the pull of gravity will tend to throw the shifter to the "off" position. All shifter handles of the same type should operate in the same direction in each shop. This will eliminate confusion when men change machines.

Belt shippers or belt poles are sometimes used in lieu of belt shifters for shipping belts on or off pulleys on overhead shafts.



Spacing of pulleys and types of belt perches.*

This is a hazardous operation unless very carefully done and is contrary to good safety practices. When necessary to ship by

* See footnote, page 186.

the use of shippers, shipper poles of the correct type should be provided and kept in a convenient location. When belt shippers are used, brackets, known as belt perches, should be used on which to hang the belt when not in service. The too common practice of allowing an unshipped belt to "ride" on the shaft should never be permitted, nor should dependence be placed on tying up a loose belt.

Clutches normally have projecting parts or rough surfaces which can catch clothing. They should be guarded with the clutch handle projecting outside the guard. This may also apply to clutches located within the frame of the machine. The handle should also be so located that the operator can stop the machine from the usual operating position.

Guarding of prime movers

Individual electric motor drives are fast replacing belt and pulley drives from line shafting; but when the latter is used, the prime mover is considered as constituting part of the mechanical power transmission apparatus and its guarding will be discussed in this chapter.

Flywheels are used to equalize speed in reciprocating engines, compressors, and other impulse equipment. The flywheel is subject to varying internal stresses and it is necessary to prevent its overspeeding or it will burst due to these stresses. The construction of the flywheel determines its safe operating speed and this should never be exceeded. Information on the safe operating speeds for flywheels of different sizes and types of construction is available from various engineering handbooks and the safety engineer should ascertain the safe speed for each flywheel in his plant and make sure that this speed is not exceeded.

While not all flywheel explosions are due to excessive speed, overspeeding has caused a large number of flywheel explosions. Overspeeding may be due to several causes, such as: breaking or derangement of the governor which may occur from a number of causes, as for example, breaking of the governor belt or gears; loss of load due to breaking of the engine belt or sudden shut-down of machines; breakage of engine parts. Flywheels may also burst from mechanical causes such as flaws in the casting or improper installation. The engine and its appurtenances should be inspected frequently to eliminate the conditions that might cause the governor to become inoperative or the engine to lose its load.

The engine flywheel should be guarded against accidental contact, the design and construction of the guard being similar to

that for other mechanical power transmission apparatus. A standard railing, with or without filled-in panels, is often used for flywheel guards and is generally satisfactory, although for some exposures a complete enclosure is preferable. Flywheel guards are intended to prevent a person from coming in contact with the flywheel, not to retain the wheel in case the flywheel bursts. No guard would withstand the impact due to the bursting of a large flywheel.

A guard should be provided along the side of the engine to prevent contact with the crank, connection rod, or crosshead. A railing guard is usually chosen so as to permit a clear view of the equipment and yet allow the attendant to adjust oil cups, feel the crosshead, and so on, by reaching over the railing. If the piston rod extends through the cylinder, this tail rod should also be guarded.

Adequate safety precautions in both the boiler room and engine room are of prime importance, for an accident to the prime mover that causes a plant tie-up is likely to involve serious or fatal injuries. Also, such major interruptions to orderly operations often bring additional injuries in their wake. Careful, systematic inspection of such vital control apparatus as governors, flywheels, overspeed engine stops, safety valves, and the like, is essential to safety and is a part of any well-organized program for protection against accidents due to mechanical power transmission apparatus.

REVIEW

1. What kind of equipment is defined to mean and include mechanical power transmission apparatus?
2. Why is metal the most satisfactory material from which to construct guards for mechanical power transmission apparatus?
3. From an accident standpoint, what is the best type of belt fastener?
4. What are the two acceptable methods of guarding belts?
5. For belts of equal size, is a flanged or flat pulley the most dangerous? Why?
6. How would you inspect a cast pulley for cracks?
7. What is a safety coupling?
8. What is a safety set screw?
9. Is a standard railing a satisfactory guard for gears?
10. What causes a flywheel to burst?
11. What causes overspeeding of an engine?

CHAPTER XIX

Guarding of Woodworking Machines

The preceding chapter discussed the fundamental principles of guarding mechanical power transmission apparatus; this chapter will deal with the principles of guarding commonly used woodworking machines, and the following chapter will treat the guarding of commonly used metal-working machines. These are the machines commonly used in many industries, and they are such prolific injury producers that a knowledge of their guarding is of vital importance to the cause of accident prevention in industry in general.

The question as to which machines, as a class, are the most hazardous is often asked. There is strong evidence that the answer is *woodworking machines.* If it were desired to ascertain the relative hazards of certain industries, the frequency and severity rates of those industries would probably be the best criteria of measurement of their hazards. These rates are based on man-hours of exposure; but since accident rates on machine-hours of exposure are not available, some other means must be found to measure the hazards of various classes of machines and of the individual machines within each class.

In lieu of machine-hour frequency and severity rates, a fairly satisfactory measure of the hazard of woodworking machines as compared to other classes of widely used machines can be derived from (a) a comparison of man-hour frequency and severity rates of industries using woodworking machines with industries using other machines; (b) a comparison of the severity of injuries, as measured by the relative number of permanent partial disabilities, that occur in industries using woodworking machines with industries using other machines; and (c) a comparison of the severity of injuries, as measured by the relative number of permanent partial disabilities, caused by woodworking machines with injuries caused by other machines. In comparing woodworking machine-using industries with industries using other classes of machines, and injuries caused by woodworking machines with injuries caused by other classes of machines, there is strong evidence to support the belief that woodworking machines, as a class, are the most hazardous of all commonly used machines.

Table 14 compares the man-hour accident frequency and severity rates of woodworking machine-using industries with all manufacturing industries combined. The data are taken from a report of an investigation of the hazards of woodworking machines published by the Children's Bureau, United States Department of Labor.[1]

TABLE 14

INDUSTRIAL-INJURY RATES FOR PLANING MILLS, FURNITURE-MANUFACTURING INDUSTRIES, AND ALL MANUFACTURING INDUSTRIES; UNITED STATES, 1936–1938

Item	Planing mills	Furniture manufacturing	All manufacturing industries
Frequency rate			
All injuries	31.74	19.14	16.18
Fatal injuries	.16	.06	.10
Permanent partial injuries	3.15	2.19	1.13
Severity rate	4.33	2.56	2.01

This table shows that for the three-year period covered, 1936–38, both the accident frequency and severity rates for planing mills and furniture manufacturing were higher than the average for all manufacturing industries combined. It is also significant, as a measure of severity of woodworking machine injuries, that both planing mills and furniture manufacturing had higher frequency rates for permanent partial injuries than the average of all manufacturing combined. The frequency rate for fatal injuries was also higher in planing mills than the average of all manufacturing, but this was not true of furniture manufacturing. The difference between the accident frequency and severity rates between planing mills and furniture manufacturing may be explained, in part at least, by the relative number of persons in each industry who operate woodworking machines. It is estimated that in planing mills about 65 per cent of all employees operate or work on machines, whereas in furniture manufacturing approximately 25 per cent of all employees operate machines. The exposure to machine injuries is, therefore, more than twice as great in planing mills as in furniture factories.

Further evidence of the fact that industries using woodworking machines compare unfavorably with industries using other types of machines in both frequency and severity of injuries may be had

[1] "Occupational Hazards to Young Workers, Report No. 4: Woodworking Machines." Children's Bureau Publication No. 277. Washington, D. C., 1942.

by comparing the accident rates of the woodworking industries with other principal manufacturing industries. Table 15 illustrates this.

TABLE 15

INJURY RATES FOR MANUFACTURING INDUSTRIES, 1941[2]

Industry	Frequency rate	Severity rate
TOTAL—all manufacturing	18.1	1.7
Chemical products	12.2	1.8
Food products	23.4	1.7
Iron and steel and their products	22.5	2.1
Leather and its products	11.8	0.9
Lumber, lumber products and furniture	41.4	4.5
Logging	96.3	14.2
Planing mills	39.3	3.2
Sawmills	54.5	6.9
Furniture, except metal	22.1	1.8
Furniture, metal	22.4	1.1
Partitions, shelves, store fixtures	21.7	2.1
Morticians supplies	13.6	1.5
Wooden containers	44.9	3.6
Not elsewhere classified	29.2	2.7
Machinery (not transportation)	16.8	1.3
Paper and allied products	23.4	2.3
Printing and publishing	7.8	0.7
Rubber and its products	16.2	1.3
Stone, clay and glass products	26.5	2.4
Textiles and their products	10.9	0.7
Transportation equipment	14.5	1.7
Miscellaneous manufacturing	14.6	1.5
Ordnance and accessories	21.1	1.4

The breakdown of industries under "Lumber, lumber products and furniture" has been given to show that the extremely high frequency and severity rates for lumbering (96.3 and 14.2, respectively) distort the true picture of the woodworking machine-using industries. But the frequency rates for those industries that do use woodworking machines to a large extent, planing mills, sawmills, wooden containers, and others not elsewhere classified, are, in themselves, higher than the frequency rates for any other major industry classification. And the severity rates of those industries using woodworking machines are also higher than the severity rate for any of the other major industries. The fact that those industries that use woodworking machines to a large extent are the ones with the highest accident rates, both from the

[2] Compiled from Table 2: Injury Rates and Injuries by Extent of Disability—Industrial Injuries in the United States During 1941. U. S. Department of Labor, Bureau of Labor Statistics, *Monthly Labor Review*, *Sept.* 1942, Vol. 55, No. 3.

standpoint of frequency and severity, indicates that woodworking machines are the cause of many and severe injuries.

Table 16 shows the proportion of permanent partial disabilities in the major classifications of the woodworking industries as compared with the proportion in all manufacturing industries combined. This comparison supports the view that these machines yield a high proportion of permanent partial disabilities. These data also are obtained from the report of the Children's Bureau, United States Department of Labor.

TABLE 16

DISABILITY DISTRIBUTION PER 1,000 INJURIES FOR LUMBER AND ITS REMANUFACTURE AND FOR ALL MANUFACTURING INDUSTRIES; MASSACHUSETTS, JULY 1, 1933 TO JUNE 30, 1938

Industry	Disability Distribution per 1,000 Injuries		
	Fatal and permanent, total	Permanent, partial	Temporary, total
All manufacturing industries	5.1	38.2	956.7
Lumber and its remanufacture	4.5	69.6	925.9
Box making (wood)	6.8	75.1	918.1
Furniture	3.0	71.7	925.3
Saw and planing mills	3.3	59.1	937.6
Other woodworking	5.5	69.6	924.9

The table shows that of every thousand injuries occurring in all manufacturing industries combined, 38.2 caused loss of a member or of use of a member, but that in the industry comprising lumber and its remanufacture, 69.6 of each thousand injuries involved loss of a member or loss of use of the member. These data are based on the annual reports of the Massachusetts Department of Industrial Accidents, and include all injuries reported to that department. Unlike New York Department of Labor compensation data referred to in a previous chapter, which include only those injuries involving a 7-day time loss, the Massachusetts data include all injuries involving the loss of one day or more. The reports, therefore, are not comparable.

Finally, Table 17, which compares the severity of injuries caused by woodworking machines to those caused by other working machines, clearly shows that, as a class, woodworking machines are the most hazardous. The data available does not permit a comparison on the basis of machine hours, but it does strongly

support the belief that more accidents occur per machine on woodworking machines than on other classes of machines. The table is from the same source as Table 16.

TABLE 17

EXTENT OF DISABILITY CAUSED BY SPECIFIED WORKING MACHINES; MASSACHUSETTS, JULY 1, 1933, TO JUNE 30, 1938

Type of Working Machine	Total	Fatal and Permanent Total Injuries		Permanent Partial Injuries		Temporary Total Injuries	
		Number	Per cent	Number	Per cent	Number	Per cent
All working machines	19,908	46	0.2	2,410	12.1	17,452	87.7
Woodworking	2,496	7	.3	462	18.5	2,027	81.2
Chemical products	79	—	—	16	(1)	63	(1)
Clay, glass, and stone products	110	—	—	8	7.3	102	92.7
Clothing	650	1	.2	10	1.5	639	98.3
Food products	1,233	1	.1	147	11.9	1,085	88.0
Metalworking	5,637	13	.2	790	14.0	4,834	85.8
Leather products	2,301	1	(1)	170	7.4	2,130	92.6
Leatherworking—tanneries	661	4	.6	51	7.7	606	91.7
Paper products	678	1	.1	71	10.5	606	89.4
Paper-making	536	3	.6	46	8.6	487	90.8
Printing and bookbinding	543	—	—	64	11.8	479	88.2
Textile	4,192	12	.3	450	10.7	3,730	89.0
Rubber, celluloid, composition, pearl, bone, and tortoise shell	765	3	.4	121	15.8	641	83.8
All other machines	27	—	—	4	(1)	23	(1)

(1) Per cent not shown because the basic number is too small to make the percentage significant.

Of the total of all injuries caused by working machines in Massachusetts in the 5-year period 1933–38, 18.5 per cent of those caused by woodworking machines caused permanent disablement of one kind or another, whereas for all working machines combined, only 12.1 per cent of the injuries caused permanent disablement. The next most dangerous class of machines on the basis of severity of injury is rubber, celluloid, and so on (15.8 per cent), followed by metal working (14.0 per cent). Other dangerous classes of machines are food products (11.9 per cent) and printing and bookbinding (11.8 per cent).

Table 18 shows the relative importance of the various commonly used woodworking machines as injury producers and also

furnishes a comparison of severity. Data are from the same source as those presented in Tables 14, 16, and 17.

TABLE 18

PER CENT DISTRIBUTION OF INDUSTRIAL INJURIES CAUSED BY WOODWORKING MACHINES, AND DISABILITY DISTRIBUTION PER 1,000 INJURIES, BY TYPE OF MACHINE; MASSACHUSETTS, JULY 1, 1933 TO JUNE 30, 1938

Type of Woodworking Machine	All Injuries		Disability Distribution per 1,000 Injuries		
	Number	Per cent	Fatal and permanent, total	Permanent, partial	Temporary, total
All woodworking machines	2,496	100.0	2.8	185.1	812.1
Lathes	57	2.3	——	105.3	894.7
Saws	1,323	53.0	2.3	192.7	805.0
Band saws	78	3.1	——	115.4	884.6
Circular saws	529	21.2	1.9	243.9	754.2
Saws not elsewhere classified	716	28.7	2.8	163.4	833.8
Drilling and boring machines, including mortisers	100	4.0	——	80.0	920.0
Planers, shapers, molders, and other surfacing machines, including tenoners	615	24.7	4.9	240.6	754.5
Planers and molders	440	17.7	2.3	231.8	765.9
Shapers	64	2.6	——	281.3	718.7
Tenoners and other surfacing machines	111	4.4	18.0	252.3	729.7
Sanding machines	98	3.9	——	81.6	918.4
Presses	57	2.3	17.5	122.8	859.7
Other woodworking machines	228	9.1	——	127.2	872.8

Saws caused the greatest number of injuries, but since more saws are used than other machines, this would be expected. No data are available on a machine-hour basis and, therefore, no true picture of frequency of injuries by machines is possible; but data on the severity of injuries, as measured by the number of permanent partial disabilities per thousand accidents, throw considerable light on which machines cause the most severe injuries.

Of each thousand injuries caused by shapers, 281.3 resulted in dismemberment or loss of use of a portion of the body. Tenoners and other surfacing machines yielded injuries resulting in 252.3 permanent partial disabilities per thousand injuries. For all saws combined, the proportion is 192.7. Circular-saw injuries are found to be more serious than those by band saws or other

unclassified saws, with 243.9 injuries of each thousand resulting in permanent disablement compared to 115.4 for band saws and 163.4 for other saws not classified. Drills and boring machines, along with sanders, show the lowest proportion of permanent disabilities.

It should be obvious that, since woodworking machines are both widely used and highly hazardous, the methods of safeguarding them, including the rules for their safe operation, must be regarded of fundamental importance. Every industrial safety engineer should have at least a good working knowledge of this subject. But since this text is intended to cover fundamentals only, this chapter will be limited to basic principles and specific points of major importance.[3]

Every woodworking machine can be adequately safeguarded for each and every type of operation for which the machine is suited. Practically all woodworking machine injuries are preventable. Numerous firms have proved this by reducing such injuries to a point closely approximating elimination. However, to accomplish this the management must take the job of eliminating them seriously; it must see that all of the proper safeguards are provided, maintained, and used; the workmen must be thoroughly instructed and trained in safe operating methods and be properly supervised. The axiom that "time gained at the expense of safety is too expensively bought" must govern.

The high speeds used in cutting or shaping wood requires a high standard of maintenance of machines and tools. A large proportion of woodworking machine injuries is due to or contributed to by vibration, dull or improperly ground cutting tools, or insecurely fastened or poorly balanced cutters. Good housekeeping, good lighting, nonslippery floors, and adequate working space about machines are also important. There follows a discussion of guarding and other safety precautions to be observed for various woodworking machines.

Guarding of shapers

The shaper is one of the most difficult of all woodworking machines to guard effectively. No single guard is practical for all the various kinds of work that may be done on a shaper, and as a result much work is done without any guard whatever. However, every shaper job can be adequately safeguarded. There is

[3] For detailed information on guarding of machines and safe operating rules, see the American Standard "Safety Code for Woodworking Plants," also Safe Practice, Pamphlet No. 20, "Woodworking Machinery and Equipment," published by the National Safety Council.

no more justification for regarding shaper injuries as unpreventable than there is for so regarding injuries from any other machine. Furthermore, the unguarded shaper is so hazardous that it can be stated with assurance that every one will sooner or later claim its quota of fingers. Therefore, whatever money and effort is required to guard each job should be viewed as a proper insurance expense against the amputations that will otherwise eventually occur. A shaper amputation is likely to cost a thousand dollars or more; this sum will pay for the safeguarding of a large number of shaper jobs, and the operator will still have the use of his skilled fingers.

Shaper injuries result mainly from unthinkingly allowing the hands to contact the knives, from the work catching and drawing the hands into the knives, from kickbacks, and from thrown knives. The fundamental principle of prevention is to provide a positive means of keeping the hands away from the knives, supplemented by eliminating the necessity of reaching close to them. This is accomplished by the use of guards to cover the knives, jigs to keep the hands away as far as possible, and the combining of these with guides to give better control of the work.

Each shaper head should be protected by an encircling guard above the knives extending out well beyond the sweep of the longest knife and adjustable to the height of the work. The guard can often be made to serve as a guide as well. Its function is to prevent the hand from coming too close to the knives or from being carried in when a kickback occurs. The guard will prevent or limit the injury in most cases. Its weakness is that it must be removed for work too large to pass under it. These encircling guards are made in a number of forms. One consists of an inverted cup-shaped cage; another, of a collar encircling the spindle; still another of a combination guard and guide which encloses the knives completely except for a section that is cut away to permit the knives to contact the work. Every shaper should be equipped with the full variety of guards suitable for all the varieties of work done on it, and proper guarding must be a fundamental part of the setup of each job.

A leather strap is sometimes attached to the spindle as a warning device; since the leather is longer than the knives, it will strike the operator's fingers before they reach the knives. This is a poor substitute for a guard and is specifically not recommended. It requires constant maintenance, gives no protection if the work catches, cannot aid in guiding the work, and its use gives evidence of management's willingness to substitute makeshifts for guarding.

All work too small to give a secure handhold at least 12 inches away from the knives should be jigged. Many shops accept

6 inches as adequate, but the records show that 12 inches is a much safer minimum. Regardless of this difference of opinion, a definite minimum should be adopted in every shop using a shaper, and its application should be rigidly enforced.

In addition to point-of-operation guarding, certain other precautions should be observed in operating a shaper. Adequate provision must be made to keep knives secure in the spindle. The desire to get all possible use out of a knife often results in the use of a knife worn so short that it cannot be clamped securely on the spindle. Shapers operate at such high speeds that thrown knives have been known to penetrate a partition wall. It is particularly important to keep the knives sharp, for the sharper the knife, the safer the machine is to operate. Care must be used in not forcing the cut, and when more than one cut is needed, the material should be lifted away from the cutter for the return, never backed up on the cutter.

Guarding of jointers

The jointer is the most dangerous machine in the surfacing-machine group. Effective guards are available for jointers but they are not always used. The bad accident experience on jointers is chiefly due to the prevalent practice of jointing small pieces without the aid of jigs to hold the work and thus keep the hands away from the knives. The most effective jointer guard consists of a metal cover somewhat wider than the opening in the table, the guard covering all of the cutter head in front of the guide. This guard is held in place by springs and is adjustable vertically and laterally. The stock being surfaced passes under the guard, which rises to accommodate its thickness. On an edging cut, the stock pushes the guard away from the guide, the guard continuing to cover all of the cutter head not covered by the work. The so-called "leg-of-mutton" guard is a wood or metal shield, pivoted so that it swings outward from the guide but covering all of the cutter head in front of the guide. In using this guard, the material being surfaced pushes the guard away from the guide, but the guard continues to cover that portion of the cutter head not covered by the work. The guard is held in place by a spring, sometimes by a counter-weight. The weakness of this guard is that in surfacing a wide board it does not cover the work and therefore does not offer as complete protection as the first type of guard.

It is important that the springs that hold the guards in position be kept properly tensioned, otherwise the guards will not return to

their position against the guide. The portion of the cutter head at the rear of the guide likewise should be kept covered at all times. This may be accomplished by installing a self-adjusting guard, which will bear against the rear of the guide regardless of its position, or a metal cover secured to the guide and projecting backward from it. A square head should never be used on a jointer; the use of such a head is prohibited by law in many states. The injuries inflicted by square cutting heads are much more severe than those caused by round heads.

Dull knives will cause kickbacks; so will too heavy a cut. As in the case of shapers, it is vital to keep the hands a safe distance away from the knives. This can be done by the use of a jig or pusher stick when jointing short pieces, but these devices are not substitutes for guards, a guard also being required. The material being jointed should be so held that the hand is not at the front of the work at the start of the cut nor at the back of the work at the finish of the cut. In most cases, the jointing of short pieces can be eliminated by surfacing before cutting to size. Many shops follow this practice, even when it involves wasting moderate amounts of stock, rather than accept the increased hazard involved in jointing short pieces.

Guarding of planers, moulders, stickers, tenoners, matchers, and panel raisers

These surfacing machines are less hazardous than shapers and jointers because they are mechanically fed and therefore the operator's hands need not come close to the cutting head. The feed rolls should be guarded to keep the operator's hands from being caught between the feed roll and the inrunning stock. The guard over the cutting head may be designed to cover this, or a separate guard may be attached to the feed-roll frame which will automatically adjust itself to the thickness of the stock being worked. These are production machines intended for volume work. They produce so many chips that an exhaust system is a practical necessity, and the exhaust hood over the cutting head performs the additional function of a guard.

The corrugations of the feed rolls should be kept clean and free from dust, pitch, and so on. They should be kept sharp by filing as needed, otherwise they may not grip the stock tightly enough to prevent kickbacks. In addition, a row of antikickback dogs should be placed in front of the feed roll to give further protection, as too thick a board, a hard knot, or a nicked knife may cause a kickback that the feed rolls cannot hold.

Guarding of circular saws

No type of saw guard yet developed affords entirely satisfactory protection for all operations that may be performed on the ordinary table saw. Quite satisfactory models are available for ordinary ripping and crosscutting, but for dadoing, grooving, and rabbetting, special guards are necessary. It is safer still to provide special machines for these types of work—machines equipped with guards suited to the operations involved.

Manually fed table-type circular saws for ripping and crosscutting are the most commonly used types of saws as well as the most hazardous. Three important features should be incorporated into every table-type ripsaw guard. These are: (a) A hood that will cover the saw at all times at least to the depth of the teeth. This hood should automatically adjust itself to the thickness of the material being cut, it should remain in contact with the material until the cut is completed, and it should afford a clear view of the line of cut. (b) A spreader that is a part of the guard. (c) An antikickback device, also a part of the guard.

The guard on a manually fed crosscut saw should combine the same feature in the hood as in a ripsaw. A spreader should be provided, although it may be independent of the guard. An antikickback device is not essential on a crosscut saw. Where a saw is used for both ripping and crosscutting, the saw guard should be of the type intended for ripping.

On both crosscut saws and ripsaws the portion of the saw underneath the table should be guarded, preferably by a complete enclosure with only sufficient opening to permit the sawdust to fall freely or to be exhausted, if an exhaust system is provided. The frequency of injuries from cleaning-up and from making adjustments with the saw running abundantly justifies this protection.

Kickbacks occur in ripping because green or twisty lumber will pinch together back of the saw and the teeth will throw it forward with great violence. In crosscutting, kickbacks are likely to occur if the stock twists when being cut or is turned at a slight angle. The function of the spreader is to prevent kickbacks from these causes. The spreader should be of strong steel, slightly thinner than the saw kerf (width of saw cut) but thicker than the saw disc, and wide enough to give adequate strength and stiffness. It should extend about the same distance above the table as does the saw, should be in accurate alignment with the saw and not over one fourth of an inch distant from it, and preferably should be curved to the contour of the saw. The spreader may be included as a part of the saw mounting, it may be permanently attached

to each throat piece, or it may be bolted to the table. Regardless of the method used for attaching the spreader, provision should be made for it to retain its relative position to the saw for whatever size saw is used.

Kickbacks are also caused by knots, unequal dryness of the lumber, forcing the work, and dull or improperly set saws. Anti-kickback devices, in addition to the spreader, should be provided on all ripsaw guards. These usually consist of two or more pointed projections, pivoted from the sides of the guard in such manner that they drag over the surface of the work when cutting; but when a kickback occurs, they dig in and stop the backward motion of the wood being cut.

When the saw is equipped for automatic feeding, the feed rolls perform some of the functions of the guard, particularly in preventing contact with the saw from the front. Even with automatic feeding, it is usually necessary to place a guard over the saw. The feed rolls help prevent kickbacks, but kickbacks can still occur unless the rolls are kept clean and the corrugations sharp. The nip-point between each feed roll and the stock should be guarded in a manner similar to that described for planers.

Swing cut-off saws are commonly used, and while they are not as hazardous as is the ordinary table saw, they should, nevertheless, be properly guarded. A hood guard enclosing all of the saw except the segment required for cutting should be provided. The guard should be so made that it pivots at the rear of the saw and rides the work at all times. To prevent the saw from being pulled forward beyond the table, or to a position such that the saw will ride the work, a limit chain or other limiting device should be provided. The saw should be counterweighted so that it will be returned by gravity to the nonoperating position back of the table when released, but it should not strike the back stop with jarring force. The counterweight should be secured against coming loose and falling.

Types of cut-off saws in which the saw is mounted on a carriage that rolls forward to the work are becoming more common. In all cases, the saw should be protected by an enclosing hood guard as in the case of the swing cut-off saw. The rollers or wheels of the carriage should be guarded, if so located that they present a finger-crushing hazard. In other types of saws the stock is placed on the carriage and rolls forward to the saw. Sometimes several saws are mounted on the same arbor. In all cases the requirements for a protective hood are the same.

In addition to the guarding, the safe operation of circular saws depends to a major extent on the proper selection and maintenance

of the saw and on the observance of safe operating rules. Except when using a universal type saw, a saw should be used only on the kind of work for which it is intended. A ripsaw should be used only for ripping and a crosscut saw for cutting across the grain only. Saws should not operate at speeds exceeding that for which their manufacturer designed them. The safe-operating speed should be ascertained from the manufacturer and never exceeded. If this information is not available, the safe-operating speeds for saws of various diameters as recommended by the "American Standard" Safety Code for Woodworking Plants should be followed.

Saws should be kept sharp and properly set. When a saw is dull it does not cut clean and straight, and its operator tends to force the work, thus causing kickbacks. When a saw is out of round, the work is all done by the longer teeth thus causing heating and "snaky" cutting. When this occurs, the saw should be "jointed," that is, the long teeth ground so that the saw is perfectly round. Saw maintenance requires highly developed skill and special knowledge and should never be undertaken except by persons qualified to perform this kind of work. The saw should be securely mounted on the arbor and should be entirely free from wobble. No adjustments of saw, guide, or guard, nor any cleaning should ever be attempted while the saw is in motion. If such work requires that the saw be rotated, this should be done by hand.

When feeding a circular saw, the operator should always stand far enough to one side to be safely out of line of a kickback should one occur. He should have a good knowledge of the properties of wood that influence its cutting. Soft woods can safely be cut faster than hard woods, and dry wood faster than green. The operator should never force the work in an effort to make it cut faster. This is not only an extremely dangerous practice but it results in bad work and will overheat the saw. When sawing narrow stock, a pusher stick should be used. This is particularly true when ripping stock only slightly wider than the distance between the saw and the guide.

Guarding of band saws

Band saws are not nearly so hazardous as are circular saws. They do not kick back, and the range of work that may be performed on them is much less. However, certain safeguards are necessary. All of the saw except the portion actually used in making the cut should be enclosed. This involves: (a) complete enclosure below the table including all of the lower wheel; (b) complete enclosure of the upper wheel, the enclosure covering the

wheel at its lowest position; (c) a U-shaped guard enclosing the return portion of the saw from the table to the upper wheel enclosure; (d) a U- or channel-shaped guard attached to the saw guide to protect that portion of the saw between the guide and the enclosure of the upper wheel. The wheel enclosures should be heavy enough to contain a broken saw and equipped with hinged covers to facilitate replacement of the saw.

In operating a band saw, the operator should stand to the right of the cut to lessen the chance of being struck by the blade in case it should break. Breaks are usually caused by forcing the work beyond the capacity of the saw or by a poor splice.

Some band resaws are equipped with feed rolls, in which case the rolls should be guarded as are other automatic feeds. The guarding required for the saw is similar to that for the ordinary band saw.

Guarding of portable saws

Many types of portable powered circular hand tool saws have come into use, particularly on construction jobs. The only type of guard reasonably satisfactory consists of a complete enclosure of the blade. The pressure of the stock being cut against a lug on the guard opens the guard to permit the cut to be made, the guard being in contact with the stock throughout the cut. However, sawdust, particularly if it is resinous or pitchy, is likely to clog up the action of this guard, and frequent cleaning and good maintenance are necessary. As in the case of all other electric-powered tools, both a pressure switch ("dead-man control") and a positive ground are important. The hazard of a tool that when dropped or laid down is not thereby automatically stopped is obviously great. And the danger from even the 110-volt circuit under conditions likely to afford a low-resistance path through the operator's body is serious.

Guarding of multiple-head machines

Machines combining two or more cutting tools in the same machine frame are used to a considerable extent to enable several types of work to be done on the one piece of equipment. They save floor space and first cost as against the cost of several individual machines to do the same work. However, they are very difficult to guard adequately and, in most cases, more than one operator cannot work on the unit at the same time without interference. For a home basement workshop, the saving in cost and space is important; for the production shop, much of this advan-

tage falls away. Such machines are specifically not recommended unless each point of operation is fully safeguarded and unless, in addition, the drive is so arranged that only one operating head can operate at a time. When designed so that all of the heads may (or in some models must) be operated together, their hazard is excessive.

Guarding of drills, borers, morticers, sanders, lathes

Few guards are possible on machines that employ revolving tools such as drills or boring bars. The chuck for holding the tool should be of the safety type, that is, without set screws or other projections. Where counterweights are used, the counterweight should be bolted to the bar, and other means, such as a safety chain, should be provided to prevent the counterweight from falling. A foot-treadle-operated machine should have a stirrup or inverted U-shaped guard over the treadle to prevent unexpected starting due to someone stepping on it or its being struck by a falling object.

Safety in operation of boring bars and similar machines depends to a large extent on the operator. Loose sleeves or neckties and gloves should not be worn when operating them. Work should always be clamped when boring, never held by hand, and the tool should be securely tightened in the chuck.

The feed rolls of drum sanders should be guarded to protect the nip-point between the roll and the stock being fed. All sanders should be provided with an exhaust system. The exhaust hood should cover all of the sanding surface except the operating area. All manually fed sanders should be equipped with work rests, guides, or aprons arranged to give the maximum of secure support for the work being sanded. Pieces too small to allow the hands to be kept a safe distance from the work should be jigged.

Lathes operate at high speed and throw knots and chips. Cutting heads may come loose and be thrown with considerable force. Chip screens should be used, and these should be made strong enough to hold a thrown head. Goggles should be worn when operating a wood-turning lathe.

REVIEW

1. Lacking machine-hour frequency rates, what other kind of accident statistical data is useful in determining the relative degree of hazard of various types of working machines?

2. As a class, what kinds of machines are usually considered the most hazardous?

3. Which woodworking machine is considered the most hazardous?
4. What are the causes of shaper accidents?
5. What are the three important features of a table-type ripsaw guard?
6. What causes kickbacks?
7. What three features are necessary on a swing cut-off saw?
8. What four features are necessary in guarding a band saw?
9. What two safety features are necessary on a portable power handsaw?

CHAPTER XX

Guarding of Metal-working Machines

Metal-working machines have probably become the most commonly used of all point-of-operation machines. Their use is not limited to any one industry; they are used in all industries manufacturing articles of metal that range from locomotives to costume jewelry. In the general category of metal-working machines are included machines for working metals hot and those for working them cold; but since hot metal-working machines are in less common usage than cold metal-working machines, this chapter will deal only with the guarding and safe operating practices of cold metal-working machines.

The preceding chapter pointed out that woodworking machines are, as a class, the most hazardous of all point-of-operation machines with respect to the severity of injury as measured by the number of injuries resulting in permanent partial disabilities (Table 17). This data shows that metal-working machines also cause a high percentage of permanent disabling injuries, exceeded only by woodworking machines and machines for making rubber, celluloid, and composition materials. Since more metal-working machines are used than any other specific types of working machines, the number of injuries caused by them exceeds the number caused by any other type of machine.

We cannot calculate the frequency rate of injuries caused by metal-working machines, as injury data on a machine-hour basis is not available. Metal-working machines do, however, produce large totals of injuries each year, a large proportion of which are severe, as is attested by the injuries reported to insurance carriers and to the workmen's compensation authorities of the various states. Their importance, therefore, cannot be overlooked when considering the fundamentals of industrial safety in the field of machine guarding.

The question is often asked as to which machines or which types of machines are the most hazardous, particularly with respect to the severity of injuries they cause. In attempting to answer the latter part of this question, it is obviously necessary to group machines according to type. Machines for working metal in the cold state can be grouped into two major categories—

machine tools, and cold metal-forming machines—although a few machines do not fit well into either classification.

Machine tools are defined as "power-driven complete metal-working machines, not portable by hand, having one or more tool or work-holding devices and used for progressively removing metal in the form of chips." The five basic functional methods of removing metal are by planing, milling, turning, drilling, and grinding. There are many variations in the form of the machines that perform these functions, for example, planers and shapers both cut metal by a planing action, and boring mills and lathes employ a turning action in that both of them rotate the stock against a stationary cutting tool.

Cold metal-forming machines may be defined as metal-working machines, other than machine tools, which change the shape of or cut cold metal by forming, punching, stamping, hammering, rolling, or shearing. Included within this class of machines are punch presses of various kinds, plate punches, power and drop hammers, rolls, brakes, and shears.

Lacking data on the frequency of injuries caused by machines of each class, information on the severity of injuries is of value in gauging the relative degree of hazard of the machine. The severity factor is best determined by the injury record. Table 19, compiled from injuries reported to the Massachusetts Industrial Commission for a 5½-year period—July 1, 1934 to December 31, 1939—furnishes a sample large enough (6,085 injuries) to permit a reasonably reliable comparison of the severity factor of the various metal-working machines.

These data show clearly that the factor of severity is higher for injuries produced by cold metal-forming machines as a class than for machine tools as a class or for the average of all metal-working machines combined. Of each 1,000 injuries caused by all metal-working machines combined, 144.61 caused permanent disablement, while 292.24 of each 1,000 injuries caused by cold metal-forming machines were permanent partial injuries. Of the injuries caused by machine tools, only 86.61 of each 1,000 were permanently disabling. Likewise, the average number of days lost per temporary total injury was higher (30.14) for injuries caused by cold metal-forming machines than for the average of injuries caused by all machines combined (25.01), and it was also higher than the average time loss for injuries due to machine tools (21.27).

Within the cold metal-forming machine group, presses and punches caused the largest proportion (314.33 per 1,000) permanent partial injuries and also the greatest time lost (30.68 days)

per temporary total injury. Hammers, shears, and rolls in descending order were responsible for the next largest proportion of these dismembering types of injury.

TABLE 19

DISABILITY DISTRIBUTION PER 1,000 INJURIES AND AVERAGE NUMBER OF DAYS LOST PER TEMPORARY TOTAL INJURY BY TYPE OF METAL-WORKING MACHINE CAUSING THE INJURY; MASSACHUSETTS, 1934–1939

Type of Machine	Disability Distribution per 1000 Injuries			Average Number of Days Lost per Temporary Total Injuries
	Fatal and permanent, total	Permanent, partial	Temporary, total	
Total—All machines	1.80	144.61	853.57	25.01
Cold metal-forming machines	(1)	292.24	707.75	30.14
Presses and punches	(1)	314.33	685.66	30.68
Hammers	(1)	245.61	754.38	(1)
Rolls	(1)	140.84	859.15	27.88
Shears	(1)	203.12	796.87	26.64
Machine tools	2.18	86.61	911.19	21.27
Abrasive wheels	2.50	74.22	923.26	17.74
Polishing and buffing	3.47	41.66	954.86	20.32
Planers	(1)	152.77	847.22	19.72
Circular saws	(1)	155.17	844.82	(1)
Milling machines	(1)	147.46	852.53	32.76
Screw machines	(1)	246.15	753.84	(1)
Turret lathes	(1)	107.14	892.85	19.06
Lathes, all other	(1)	88.01	904.64	18.93
Boring mills	(1)	79.36	920.63	22.68
Drills	(1)	57.25	942.74	26.41

(1) Rate not shown because base is less than 50.

In the machine-tool group, screw machines, circular saws, planers, and milling machines were in the order given responsible for the highest proportion of serious injuries. The data are incomplete for average time losses of temporary total injuries, but milling machines cause an extremely high time loss.

Since cold metal-forming machines as a class are shown to be more hazardous than machine tools with respect to their severity factor, the problems involved in their guarding will be considered first.

Guarding of cold metal-forming machines

Power presses. Power presses are usually defined to mean and include all machines operated by mechanical power fitted

with one or more rams and dies for the purpose of blanking, trimming, drawing, punching, or stamping materials. The diversity of work that can be performed on power presses has led to the designation of the press by the kind of work performed, such as blanking press, punch press, trimming press, stamping press, assembling press, riveting press, straightening press, and so on.

The wide variety of work done on presses makes adequate guarding difficult. There is no universal guard suitable for all presses and all kinds of work. On the other hand, a press operating wholly on any given kind of work can readily be guarded satisfactorily. Short runs, particularly on job presses, offer the most difficult problems because, while every operation can be guarded, the time and expense necessary to do so may seem prohibitive. This is particularly true if the expense of guarding is charged against the job being done. It would be much better to charge guarding as a general expense spread over the entire shop than to charge it against one particular manufactured article or machine.

Where short runs are the rule and special guarding not practicable, the best solutions seem to be to provide guards suitable for any work that might be done. Their cost can thus be spread over the life of the press. This is the method used in plants that appreciate fully the seriousness of accidents and the money value of eliminating them. The money spent on guards may well become a profitable investment, if it prevents only a single serious injury.

The problem of guarding is influenced largely by the method of feeding, which in turn is largely dictated by the length of the run of the particular job being done. The three methods of feeding are: fully automatic, semiautomatic, and manual. Where a fully automatic feed is used, the operator places the material en masse into a hopper, magazine, feed roll, or other device which in turn automatically conveys it under the die. By semiautomatic feeding is meant placing the article singly or a few at a time into a chute, slide, sliding die, dial, or other device which in turn feeds each piece to the point of operation. In manual feeding, the operator places each piece individually under the die and usually removes it after the operation has been performed.

Any press operation can be made reasonably safe; the more fully automatic the method of feeding, the easier to guard adequately. Effective guarding will increase, not decrease, production. If the operator knows that he cannot reach into the danger zone, he can concentrate on operating the press at its maximum capacity. Mechanical feeding, either fully automatic or semi-

automatic, produces steadier operation and higher press speed is possible. The production increase alone will, in many cases, justify the change-over from manual feeding to mechanical feeding. If the additional safety of the operator is considered, there is a further incentive to eliminate, as far as possible, hand feeding. Many jobs that are now fed manually because of the short runs could, in all probability, be more economically and safely performed by semiautomatic feeding.

Since a fully automatic feed permits full safeguarding, this method of feeding should be used whenever possible. In some industries, automatic feeds have been developed to a marked degree. This is particularly true of large companies specializing in light-weight metal products such as cans, small tin boxes, metal spools for adhesive tape, and the like. Several of the large can companies have developed automatic feeding to such a degree that many of their products are completely made, from the first blanking-out operation to the assembly of several component parts, without being touched by human hands. The fact that it is not necessary for the machine operator to get near the point of operation would of itself make the operation of these machines relatively safe. In addition, a complete enclosure of the danger zone, with the guard interlocked with the driving mechanism so that the machine cannot be operated unless the guard is in place, is used to make these machines almost completely accident proof.

Automatic feeding does not eliminate the necessity for guarding the point of operation, but it makes guarding easier. Since it is unnecessary for the operator to place his hands under the plunger, the danger zone of the press can and should be fully and permanently enclosed. This enclosure of the ram may be permanently bolted into place or a gate guard may be used. When a gate guard is used, it should be interlocked into the driving mechanism so that the machine cannot be operated unless the guard is in place. It is also accepted practice, when it is possible, to limit the ram stroke to $\frac{3}{8}$ inch so that no guard will be required.

When fully automatic feeding is impracticable, semiautomatic feeding may frequently be used. Great progress has been made in the last few years in developing semiautomatic feeds. Insurance companies who write workmen's compensation insurance for large users of punch presses have been particularly active in this work. Some of them employ expert designers who will design the equipment, including the die, to eliminate hand feeding. As in the case of fully automatic feeds, semiautomatic feeds do not eliminate the necessity for guarding. For maximum safety, access to the danger zone while the press is in motion must also

be impossible. Acceptable methods of guarding presses employing semiautomatic feeding are by a complete enclosure of the ram, limitation of the ram stroke, or a gate guard.

Automatic ejection of the material from the press is necessary where automatic or semiautomatic feeding is employed and is desirable when the press is manually fed. Many methods are employed to do this. Sometimes a blast of compressed air is used to blow the finished product out of the press; hollow dies may be used, which allow the work to drop through the die into a container; or a spring ejector may be placed on the lower die which will push the material out of the die and allow it to slide into a receptacle. Most presses are made so that they can be tilted, and tilting the press is often all that is necessary to provide for automatic ejection. Strangely enough, this fact is often overlooked. The finished product is frequently removed from the press by hand while gravity would remove it automatically if the press were tilted.

Hand feeding is by far the most hazardous, and this method of feeding should be employed only as a last resort. When manual feeding is done, it is absolutely necessary that the most effective possible method of guarding be used. There are several fairly effective methods: by limiting the stroke of the ram to 3/8 inch, by a gate guard that closes off the danger zone before the ram descends, or by a two-handed tripping device. If the latter device is used, it should be so designed that both handles must be actually operated for each stroke of the press. On some two-handed tripping devices, it is possible to tie down one handle, using only the other. This type of guard is not safe and should never be used. When more than one person is required to operate a press, there should be a control for each hand of each operator in reach of the zone of danger. Gate guards are also used; one type falls ahead of the plunger and, if it meets any obstruction, such as the operator's hand, instantly stops the travel of the plunger.

Guards are also available which pull the operator's hands away from the danger zone as the ram descends, being actuated by a series of ropes operating over pulleys. Special hand tools may also be used to insert stock into or remove it from the press, but because their effectiveness depends upon unfailing use, many safety engineers place little confidence in them. Sweep guards are also used. This type of guard consists of a rod, actuated by the plunger, and is so pivoted as to sweep across the opening of the press as the ram descends, thus brushing the operator's hand aside. This type of guard is generally unsatisfactory as it is difficult to so adjust it that the operator cannot reach around it.

If the sweep operates fast enough, it can also strike hard enough to cause an injury.

In addition to guarding the point of operation, presses need guarding from other hazards likely to cause injury. Each press must be equipped with a powerful brake, one that will prevent the press from overrunning the stroke and will stop the ram dead when the treadle is released. For many types of press work, particularly where manual feeding is used, a nonrepeat device is necessary. The nonrepeat device is intended to prevent the operator from riding the treadle, that is, operating the press continuously by keeping the treadle depressed. Nonrepeat devices are of several types, operating either by means of a single-stroke clutch or a mechanical arrangement that disconnects the treadle after each stroke of the clutch. A guard should be placed over the treadle to prevent accidental operation of the press should something fall on the treadle or it be accidentally stepped on.

Means should be provided to block up the plunger when changing dies. Dies should be changed only when all power has been disconnected and the press should be turned over by hand for the first few strokes to make sure that the die operates properly.

Presses can be made as safe to operate as any other machines by a combination of practical guarding, the proper design of the die to include such factors as ease of feeding and automatic ejection, and by the proper selection and training of personnel to operate and service them.[2]

Cold metal hammers. Cold metal hammers are another type of machine with a bad safety record. Hammers are used extensively in the cold working of nonferrous metal, particularly in the cutlery industry. Hammers are of many types, some operating by gravity, others through applied power; some with dies, others without. A full discussion of the function and method of operation is beyond the scope of this text, but the major hazards and the means of safeguarding them will be discussed briefly.

The most hazardous work connected with cold metal hammer operation is in changing the die. The dies are very bulky and heavy, difficult to change and to adjust. When changing dies the hammer should be blocked up, a piece of heavy timber such as an 8-by-8-inch block being used, and a safe means of handling the dies should be provided. A table with an adjustable top, so that the die can be slid into place without lifting, has been found

[2] For detailed information on methods of guarding and other safe practices to be observed in the operation of power presses, the American Standard "Safety Code for Power Presses and Foot and Hand Presses" and Safe Practices Pamphlet No. 18, "Power Presses," published by the National Safety Council should be consulted.

to be very helpful. Shield guards of heavy sheet metal should be placed around the anvils of drop hammers to prevent scale or other particles from flying. The scale guard may be hinged or pivoted into place so that it can be swung out of the way when changing dies. When a treadle is used, a stirrup guard should be placed over the treadle to prevent accidental operation.

Metal shears. Shears are another class of cold metal-working machines which cause many disabling injuries, particularly amputations of fingers and hands. There are three principal types of shears: alligator, guillotine or squaring shears, and slitters or circular shears, the latter being probably the least hazardous.

Alligator shears are frequently used in junk yards and in production shops for cutting light bar stock. Many of them operate continuously even when not in use. Frequently they are installed facing an aisle or a work place used by many persons. Many distressing injuries have occurred because someone in passing slipped and, in trying to keep from falling, thrust his hands into the shears. Hard stock is likely to be thrown with great force when cut, or chips may fly from the knife. Shears should be provided with means of shutting off the power when not in use.

The hazards of operating alligator shears can be reduced. The clearance between the jaws should be limited, 3 inches being the accepted standard. A heavy U-shaped metal guard should be placed around the moving jaw and, when possible, a method of feeding, preferably automatic, should be developed that will keep the operator well away from the shears.

Squaring shears should be provided with barrier guards at front and rear of the knife, set less than the thickness of a finger above the bed so that it is impossible to reach under the knife, but so arranged that the operator can see the line of cut. A hold-down device, which descends ahead of the knife, should be installed to hold the material in place while it is being cut. When two or more operators are required to handle materials into or out of the shears, the operating mechanisms should require that each operator's hands be on the controls before the shears can be tripped.

Brakes. Brakes for bending sheet metals operate in the same manner as squaring shears, the only difference in the machine being that a straight edge for bending instead of a knife for shearing constitutes the tool. Brakes can be as dangerous as shears, and the same principles of guarding should be employed.

Cold rolls. The other major group of cold metal-forming machines is cold metal rolls. Rolls consist of two or more individual rolls and are used for bending, crimping, corrugating, knurling, or otherwise changing the shape of the metal or for

reducing the thickness of metal sheets or plates. Rolls are much less dangerous than the other cold metal-forming machines, chiefly because of their slower speed.

The intake point should be provided with a stationary guard which will prevent the hands or the clothing of the operator from being drawn into the rolls. Unless the size of the material being rolled prevents it, the opening between the guard and the nip-point should not exceed ⅜ inch. The machine control should be placed as near the run-in point as possible, so that the operator can stop the machine if he should be caught in the in-running rolls. This may be accomplished by placing a bar operating the clutch or starting mechanism across the front of the roll in such a way that it will be displaced by the arm or the body of a person caught in the roll, thus stopping the machine. Rolls usually operate quite slowly and can be stopped quickly when power is removed.

Guarding of machine tools

Machine tools as a class cause less serious injuries than do metal-forming machines; but because of their greater use, the number of injuries caused by them is probably greater than from any other class of machines. The fundamental principles involved in their guarding and suggestions for their safe operation is, therefore, included as a part of this text. For discussion purposes, machine tools will be grouped together by the functions they perform.

Milling consists of machining a piece of metal by bringing it into contact with a rotating cutter with multiple cutting edges. The commonest machine of this class is the ordinary milling machine of either the horizontal or vertical type. Also included in the milling-machine group are planer-type milling machines, gear hobbers, and special machines employing one or more milling cutters in conjunction with other types of tools.

One of the features that makes a milling machine potentially dangerous is that not only is the tool rotating but also the work is in motion. The operator must be on his guard against both movements. Little point-of-operation guarding is possible on a milling machine, but some type of guard should be used over the cutters wherever possible. Such a guard may be of metal, or, where necessary to see the work, it may be made of transparent material. It should fit as close to the periphery of the cutter as possible and, preferably, should be adjustable to cutters of different sizes. The cutter guard performs two functions—it prevents accidental contact with the cutter head, and it acts as a permanent chip guard.

The control mechanism, usually "start" and "stop" buttons or levers, should be located within the reach of the operator from his normal working position. This is necessary for the operator's safety and desirable for efficiency.

Safe practices on the part of the operator are necessary if the milling machine is to be operated safely. Some of the most important safe practices are mentioned briefly as follows: Chips should never be removed with waste; the only safe way is to stop the machine and use a chip brush. The practice of tightening the arbor nut by using the power of the machine has caused many accidents and should never be permitted. The arbor nut should be adjusted by hand, and the cutter should be placed as far back on the arbor as possible. The material being worked on must be clamped securely and no adjustments of either the tool or the work should be made while the machine is operating. When using the automatic feed, the hand wheel on the table should be disengaged so that it does not revolve. And, since the cutting tool employs a rotating motion, it is especially important that loose clothing should not be worn by the operator.

Planing consists of machining a surface by moving the work back and forth under a stationary cutting tool or by holding the work stationary under a reciprocating tool. Machines in this class include planers, shapers, and broachers. While these machines are not particularly hazardous, several fundamental principles of guarding them should be observed.

The openings in the bed of the planer should be filled in with sheet metal if the bed is not built with a solid web between runways. This procedure will prevent using the space under the table for storage of tools or the like. Many persons have been severely injured when their arms were caught between the frame of the planer bed and the moving table. The opening in the frame housing should also be filled in to prevent the operator from reaching through the housing and being caught between the work and the housing.

The clearance at the end of the table when extended the maximum distance should be not less than 18 inches, preferably 24 inches. If less than this, a guard rail should be provided to prevent the passage of a person between the table and the wall or other object. On large planers, a runway between the uprights is sometimes provided. The runway should be equipped with a guard rail and a toe board. And it is considered good practice to place a shield guard over the reversing dogs so that they cannot be inadvertently displaced and so strike the operator.

Some of the precautions necessary for safe planer operation include the following: The material to be planed must be securely clamped on the table and the operator must make sure that it will clear the housing before he starts the machine. When changing stop dogs, the machine should be shut down; they should never be changed while the machine is in motion. On some very large planers, it is possible for the operator to ride the table; but this practice should never be permitted.

The other important machine using a planing action is the shaper. Little mechanical guarding is possible or necessary on this machine. Sometimes a permanent chip guard may be used to good advantage, but this is not always practicable. A clearance of from 18 to 24 inches should be maintained at the end of the ram; but when this is not possible, the opening between the ram and the fixed object should be fenced off to prevent passage. It is also considered good practice to turn the machine over by hand for the first few strokes to be sure that the ram clears the table and the work.

Turning consists in shaping a rotating piece by revolving it against a cutting tool, thus generating a cylindrical surface. Machine tools coming under this category include all forms of metal-turning lathes, including automatic screw machines and boring mills.

On large lathes a sheet-iron shield should be placed over the chuck to prevent contact with the revolving parts of the chuck. This can be made in two or more parts so that it can be moved out of the way when putting the stock in the chuck. Safety lathe dogs, that is, dogs without protruding set screws, should always be used. In cutting certain kinds of materials, particularly cast iron, brass, and other nonferrous metals, a serious hazard is created by flying chips. It is often practical to install a permanent chip guard, but this does not as a rule eliminate the necessity of the operator wearing goggles.

Safety in operating a lathe depends to a great extent on safe practices. Loose clothing should not be worn. A brush should be used for removing chips, and the machine should be stopped when calipering. Dermatitis can result from cutting oils, and means should be taken to prevent it. When putting on a face plate, it should be done manually, never by using the power of the machine.

On lathes where the stock extends beyond the machine, such as turret lathes and automatic screw machines, provision must be made for guarding the stock to keep it from whipping about and

to prevent contact with it. A section of pipe, properly supported, through which the bar stock is fed makes an excellent guard and one that is much better than an open support.

Since a stream of coolant, usually a cutting oil, is maintained on most automatic machines, a guard should be installed to prevent the coolant from being thrown. Drippage and spillage are caught in suitable pans and drained back into the system. Floor mats, to prevent slipping, may also be necessary.

The boring mill is another machine tool in which the rotating stock is brought in contact with a stationary cutting tool. Safe operation depends more on safe practices than on mechanical guarding, but guarding reduces some of the hazards. A sheet-iron guard is advisable around the table to prevent contact when the mill is in operation. This guard should be hinged so that it can be opened when the work is being placed.

It is advisable to guard the counter-weight on the boring mill with a solid complete enclosure. When setting up the job, the work must be securely clamped and all tools removed before the machine is started. The practice of riding on the table should never be permitted except when setting-up a very large mill.

Boring or *drilling* consists of cutting a round hole by means of a rotating cutting tool. Machines in this class are drills, reamers, and honers. The mechanical guarding of these machines is largely confined to the guarding of belts, pulleys, gears, and set-screws discussed in a previous chapter. Mechanical guarding is important, however, particularly on drills. Where women are employed as operators, guarding is particularly important. A telescoping guard is sometimes used over the drill, and where such a guard is practicable it should be used.

Drills, like many other machine tools, depend chiefly upon safe operating practices for their safe operation. The stock being drilled should be clamped rather than held. A chip brush should be used to remove chips; using waste or gloves should never be permitted. Loose, flowing clothing such as neckties or long sleeves are particularly dangerous when worn at work about a revolving tool such as a drill. When a woman operates a drill press, she should wear a cap that completely covers her hair. Goggles should be worn when using a sensitive drill or other type of hand-fed drill that requires the operator to watch the work closely. One of the dangers of drill-press operation is that met when changing drills. The spindle should be lowered close to the table to prevent the chuck and drill from falling, and the drill should never be changed while the machine is in motion.

Grinding consists of shaping metal by bringing it into contact with a rotating abrasive wheel. Grinding may be internal or external, flat or cylindrical. Polishing, buffing, and lapping are also considered as parts of the grinding process. The four principal hazards of grinding are: injury to the eyes from flying particles; inhalation of dust generated by the grinding process; the danger due to bursting of the wheel; and accidental contact with the revolving wheel. All of these hazards can be eliminated or diminished by mechanical guarding or the use of personal protective equipment, or both.

Protection to the eyes is best accomplished by the use of goggles. Lately, plastic faceshields have come into increasing use, but there has not been sufficient experience with them to ascertain their effectiveness for grinding operations, and dependence on them alone is not recommended. A permanent eye shield should be installed on all machines used by anyone in the shop, as, for example, an emery wheel stand used for sharpening tools.

All production grinding wheels should be equipped with an exhaust system to remove the dust at the point of origin. Grinding dust consists not only of particles of the wheel itself but also of minute particles of the metal being ground, and its inhalation represents a serious health hazard. For most grinding-wheel installations, with the possible exception of certain swing grinders used for rough grinding of castings, the protection hood is built as an integral part of the exhaust system.

Protection to the operator in case the abrasive wheel bursts is accomplished in two ways—by protection hoods, and by protection flanges, chucks, or bands. The details as to construction of protection hoods and flanges, chucks or bands, is beyond the scope of this text but is available from other publications.[3] Protection hoods, in addition to keeping pieces of the broken wheel from striking the operator, also prevent accidental contact with the wheel and funnel the dust into the exhaust system. Protection flanges, chucks, or bands act to hold the wheel together if it should break in operation.

Abrasive wheels may burst from a number of causes, such as overspeeding, improper mounting on the spindle, grinding on the side of the wheel, jamming of the work between the wheel and the work rest, or a combination of these or other causes. Abrasive wheels should be marked by the manufacturer to indicate the maximum speed of operation, and this should never be exceeded.

[3] American Standard "Safety Code for the Use, Care, and Protection of Abrasive Wheels," also Safe Practices Pamphlet No. 13, "Grinding Wheels," of the National Safety Council.

Wheels should be inspected before being used or after remaining idle for any length of time. One method of testing is the ring test. When struck by a wooden mallet, a vitrified or silicate wheel gives a clear metallic ring if the wheel is sound. A bursting abrasive wheel can cause great damage and loss of life, and every precaution must be taken to prevent injury that might cause one to burst. It is important that wheels be properly stored, mounted, and used. Fortunately, better-designed and better-made wheels, along with the excellent work of manufacturers in educating the users in the proper care and use of their products, have greatly reduced the frequency of grinding-wheel explosions.

This chapter is intended only to highlight the guarding of metal-working machines and to point out the basic principles underlying such guarding. In addition to standard models of machine tools employing the five functional methods of removing metal, there are literally thousands of special machine tools, designed and built to do special jobs. Many of these special machines, as well as standard machines used for a special purpose, require individual guarding treatment. Standard guards are not usable, and protection must be provided in the design of the machine or added by the safety engineer in the plant of the user.

REVIEW

1. Do machine tools or cold metal-forming machines, as a class, cause the more serious injuries?

2. What is the most important factor in the safe operation of punch presses?

3. What are the hazards of operating abrasive wheels and how can each hazard be overcome?

4. What mechanical guarding is necessary on a planer?

5. In addition to a point-of-operation guard, what other safety devices or precautions are necessary on a punch press?

6. How are squaring shears guarded?

7. How are alligator shears guarded?

8. How are bending rolls guarded?

9. What kind of guard can be used on a milling machine?

10. Name four safe practices necessary to operate a milling machine safely.

11. What important guarding is necessary on a turret lathe where the stock extends beyond the machine?

CHAPTER XXI

The Prevention of Falls

Falls are one of the chief sources of occupational injury. Data from agencies administering workmen's compensation acts usually show that for all types of industry combined injuries from falls are exceeded in number only by those from "handling."[1] For example, during a typical five-year period in the state of New York, the proportions of total compensated injuries from these two sources were handling 29.3 per cent, falls 21.9 per cent. For Pennsylvania, a typical year showed handling 23.8 per cent, falls 18.1 per cent. However, in the manufacturing industries mechanical apparatus comes second with falls third. For New York manufacturing industries during the typical five-year period the relationship of these sources was handling 29.2 per cent, mechanical equipment 28.3 per cent, falls 13.1 per cent. In many kinds of industry and in many occupations falls is the chief injury source. Among occupations responsible for falls are overhead maintenance, overhead construction, rigging, painting, and many types of outdoor work.

In industry as a whole falls to the same level produce somewhat more injuries than do falls to a lower level. Obviously, the chance of injury in falling to a lower level is high, but the greater frequency of falls to the same level more than makes up for this difference. In certain industries, of course, as building construction, and in occupations involving much overhead work, falls to a lower level predominate.

In theory, falls are wholly preventable. In practice, their elimination is exceedingly difficult because it involves great detail and the practically faultless performance of everyone concerned (workmen, supervisors, architects, engineers, management, maintenance forces, and so on). Perhaps one reason why the necessary high level of performance in this respect is so difficult to secure and maintain is that we are all used to falls from childhood on. A child learns to walk largely through the tumbles he takes. Adults become careless in their walking and working and take their

[1] "Handling," as used herein, means the lifting, moving, placing, transporting, or turning of objects where such action is the primary purpose.

tumbles too; they fail to keep the hazard of falls sufficiently in mind and do the numerous things that produce falls, or, more fundamental still, fail to take all the detailed precautions they should to lessen the chance of falls by themselves or others. The prevention of falls may be classified under the following broad headings:

1. Safe surfaces on which to walk and work.
2. Safe means of access to overhead points.
3. Safe arrangement and design.
4. Safe footwear.
5. Safe practice.
6. Housekeeping and order.

Typical defects

The permissible length of this discussion does not allow all-inclusive treatment. However, typical defects of floor surfaces, stairs, ladders, portable steps, and sawhorses are listed in the following pages. In most cases, the means of correction is suggested by the defect. The comments in the right-hand column are indicative.

Defective Condition	Means of Correction
1. **Floors:** *a.* Holes, depressions, unevenness, wear, sag, working overload. *b.* Projections, as edges of gratings, pit covers, pipes, conduits, etc. *c.* Uncovered gutters or drains. *d.* Slipperiness due to wear, grease, oil, water, loose particles, as sand or sawdust. *e.* Slipperiness due to use of material with low coefficient of friction, as marble or smooth steel. *f.* Vibration, springiness, slope.	Management must cultivate an awareness of floor hazards. Systematic inspection, provision for prompt repair and correction of all defects. Forethought for safety in all construction, alterations, additions. Provision of safe load values and maintenance of loading within safe limits.
2. **Stairs.** Common defects are: *a.* Treads—slippery, worn, split, broken, deformed, nonuniform in width, sloping, springy, weak, lack of nosing. *b.* Risers—nonuniform in height, not filled in. *c.* Railing—loose, weak, missing, improper height, lack of hand clearance. *d.* Design faults—too steep, too narrow, too wide (between railings), flights too long, landings too narrow, opening directly onto traffic.	Protection for construction jobs and restoration of safe condition. Careful housekeeping, prevention of spillage, drippage, and leakage. Provision of antislip surfaces, sections, or treads. Use of antislip finishes or floor coverings. Excellent maintenance. An excellent all-purpose stair will[2] have 7″ risers, 11″ tread, plus 1″ nosing, riser height and tread width uniform within ⅛″, clear width not less than 36″ nor over 88″, both sides railed if 44″ wide or over, railings not less than 30″ nor more than 34″ from

[2] See Safe Practices Pamphlet "Stairs," published by National Safety Council.

Defective Condition	Means of Correction
e. Lighting—too little, glare, shadows, light control, inconveniently placed.	upper surface of top rail to surface of tread in line with face of riser at forward edge of tread, antislip tread surfaces.
3. **Fixed ladders:**[3] *a.* Rungs—uneven spacing, bent, loose, missing, worn, greasy, weak, insecure, nonuniform replacement. *b.* Rails—bent, split, improperly repaired, weak. *c.* Location or placing—inadequate toe clearance at back, hand clearance at rail, shoulder clearance at side, lack of hand holds at top, too narrow or too wide, outward slope, too near traffic.	A fixed ladder should have 12″ rung spacing, 18″ minimum rail spacing, clearance at back of ladder not less than 6½″ at any point, rails carried up above platform or roof and goosenecked or otherwise arranged to give handhold 42″ high; on ladder 20′ long or over there should be cages 24″ wide, 20″ deep starting 7′ from floor or ground level.
4. **Portable straight ladder:**[4] *a.* Rungs—Nonuniform spacing, broken, missing, worn, loose, weak, improperly repaired or replaced, insecure, dirty. *b.* Rails—split, yielding, weak, improperly repaired. *c.* Antislip feet—lacking, wrong type for purpose. *d.* Design and construction—lack of batter, unsafe construction, concealing finish, improper material.	Portable straight ladder should have 12″ rung spacing, ¼″ batter per foot, rungs extending through rails and secured to prevent turning, at least two metal cross braces, clear straight-grained material, oil or varnish finish, antislip feet.
5. **Stepladder:** *a.* Steps—worn, broken, split, missing, loose, weak. *b.* Rails—bad condition, weak. *c.* Spreader—locking, nonlocking. *d.* Design and construction—Inadequate batter, weak, too long, unsteady, concealing finish.	Lattice-type stepladders not recommended, positive locking spreaders, treads spaced 12″ on centers, securely fastened.
6. **Portable steps:** *a.* Bad condition. *b.* Design and construction—inadequate batter, weak, too high or uneven risers, unsafe assembly, lack of railing.	Portable steps over 4′ high should be railed. Side batter not less than 1″ per foot of height.
7. **Saw horses:** End overhang, inadequate batter, inadequate bracing, weak, bad assembly, bad condition.	Legs should be through bolted. End batter should be equal to overhang. Legs should be cross braced and angle should be braced.

Scaffolds

A wide variety of scaffolds are in quite common use. The outline below is limited to the barest fundamentals of scaffold safety involving the following:[5]

[3] See Safe Practices Pamphlet "Ladders."

[4] See American Standard "Safety Code for Construction, Care and Use of Ladders," published by American Standards Association, 29 W. 39th Street, New York, N. Y.

[5] For details of scaffold construction see "Manual of Accident Prevention in Construction," Associated General Contractors of America, Washington, D. C.

1. Suitability for work to be done.
2. Soundness of materials used.
3. Design to include at least:
   a. Adequate railing.
   b. Toeboards.
   c. Ample factor of safety.
   d. Secure support or attachment.
   e. Stability.
   f. Safe means of access.
4. Provision for maintenance.
5. Consideration of relationship to other operations and equipment to avoid incidental hazards.
6. Selection of personnel suited to scaffold work.
7. Careful training and supervision.
8. Maintenance of good housekeeping.

Overhead work in general

Much of the foregoing applies to overhead work, but the following comments are of general applicability:

1. All overhead equipment of whatever nature must be serviced at short or long intervals, and suitable provision for such service should be provided for or at least planned for when the equipment is installed. The factors to be considered are:
   a. Frequency of servicing required.
   b. Nature of service required.
   c. Number of workers required.
   d. Weight of tools and equipment likely.
   e. Adverse exposures likely.
   f. Incidental hazards that may be involved.
2. Overhead work involves special hazards and requires special abilities. Planning should, therefore, be very careful and thorough, covering at least:
   a. Personnel to be used.
   b. Instructions to be given.
   c. Special safety equipment and safeguards needed.
   d. Clearance with those in charge of other activities or operations.
   e. Possible emergencies or untoward developments.
   f. Adequate supervision.

Footwear

Unsafe footwear contributes to or causes injuries in many ways. Much attention is rightly being given to the wearing of safety shoes of various types, but it appears probable that falls due, in whole or in part, to improper footwear produce more injuries than do the lack of safety shoes.

Loose or worn soles or heels cause tripping, slips, and stumbles. Loose lacings, buckles, and fasteners interfere with one's stride. Run-down heels bring bad balance and resulting strain, turned ankles, and fatigue.

High heels are very bad. They cause falls through bad balance, bad gait, foot discomfort, foot deformation, and tendon strain. The tiny heels catch in gratings and crevices and slight irregularities; their small bearing surfaces increase slipping. Whether or not anything very effective can be done to discourage the production and wearing of these "instruments of injury" is a question. It will apparently be necessary to bring about a radical change in the sales approach in the shoe trade, as well as in the feminine viewpoint.

It is possible for any industrial establishment to secure a reasonably good degree of conformity with requirements for safe footwear within the plant, however. Three measures are necessary:

1. Provision of the specified footwear at prices no higher than the employee is accustomed to paying.
2. Convenience of supply and correct fit.
3. A system of arousing and maintaining interest in safe footwear coupled with a continual checking on performance in a helpful coöperative manner, rather than dictatorially.

Safe practice in walking

Given good walking and working surfaces and safe footwear properly maintained, we will still have falls due to unsafe practices in walking and working. Each person should cultivate safe walking practices. For instance, Indians and woodsmen are traditionally sure-footed; for, if one is to keep his footing at all in the woods, he must pay attention to his walking. It is as feasible and often as necessary to stimulate and instruct in safe "foot work" as in other phases of safety. A stair furnishes an excellent example. Falls on stairs, despite good stair condition, yield a continuous stream of injuries. Few persons give any thought to safe stair use and consequently few use stairs safely. The forming of safe stair habits is personally important to everyone, though few seem to realize it enough to do anything effective about it.

Housekeeping and order

The subject of housekeeping in general is dealt with in another chapter. However, the importance of individual attention to good housekeeping and good order justifies its mention here. A very substantial share of falls "on the job" come from simple failure to have "a place for everything" and to keep the job orderly. We find perhaps the fullest appreciation of the value of

orderliness in another field, that of surgery. Any layman watching an operation will be impressed by the meticulous attention that is given to orderliness. If this is necessary in repairing human wreckage, it should be similarly seen as necessary in preventing injuries likely to require the services of the surgeon.

REVIEW

1. How important are falls as an injury source?

2. Which produce the greater number of injuries, falls to the same level or those to a lower level?

3. Can practically all falls be prevented?

4. Why is it difficult to prevent them?

5. Give what you believe to be the five commonest defects of floor surfaces that "make for" falls.

6. Describe a safe stair.

7. Describe a safe portable straight ladder.

8. Describe a safe fixed ladder.

9. Give eight fundamentals of scaffold safety.

10. Give six fundamentals of safety on an overhead job.

CHAPTER XXII

Methods of Promoting Safe Practice

The essentials of first-rate safety performance in any establishment have been likened to an equal-sided triangle, two sides of which are, respectively, safe plant and safe practice resting on the solid base of management interest. Or, putting it a little differently, if any management really wants good safety performance, it can get it. It can make its plant safe; it can develop a high standard of safety-mindedness in its working force; and it can maintain a program of preventive effort that, based on these two essentials, will practically eliminate accidents.

While much in preceding chapters bears on the promotion of employee interest in safety—in other words, employee safe practice—this and the three following chapters are devoted specifically to major phases of this basic element of safety. The means and methods used to develop, improve, and maintain worker safe practice have been dealt with under varying titles by different authors. For the purposes of this discussion, the following classification will suffice:

1. The essentials of safety salesmanship.
2. The organized safety sales program.
3. The safety inventory.
4. Safety organization.
5. Safety training.
6. The new employee.

The essentials of safety salesmanship

Getting men to work safely is primarily a sales job. It has to be. Men can be ordered or even compelled to do things, up to a point, but compulsion cannot get really good performance in anything. Only interest—the desire to do good work—can bring superior accomplishment. Enforcement of at least minimal acceptable safety practice may at times be necessary. When it is, however, it merely means that the sales effort has failed with the person or persons involved and, therefore, it is necessary to use that very poor substitute, enforcement, pending the time when the sale can be made.

The subject of salesmanship has been abundantly dealt with in widely known and well-accepted texts which anyone wishing to study selling in detail should consult. However, fundamentals deemed of major importance to the safety man are presented here in brief fashion.

Essentials of a sound sale

Many things are sold that should not be; others are sold to perform more or better than they actually will—all of this without any actual fraud, perhaps, but no such sale is sound. The first essential, then, is a good product. A product is good only if it yields the purchaser a profit on the transaction, a profit in service or pleasure or satisfaction or some other value. Surely safety is such a product. It brings the employee freedom from injury and suffering and loss of wages and bereavement and hardship for his family. And it saves money for the employer and brings him more and better production, a more smoothly running organization, and better repute. It saves loss to the community and to the nation. The salesman of safety should be very careful to make no exaggerated claims for his product. The truth is enough.

The next essential is that the salesman must know his product. There is no substitute for hard study, attention to detail, and clear thinking, if one is to acquire a good mastery of any subject. This is perhaps more true of safety than of many other lines, because safety covers so broad a field.

The third vitally important point is that the salesman should always endeavor to watch his sales effort from the point of view of the prospect. Of course, given a good product, any salesman who merely "goes out and talks about it" and exposes himself to enough possible customers will make some sales; but that is not effective salesmanship, it is really advertising; and while advertising has a sound place in any safety program, it cannot take the major role. Too many safety programs consist of little else. Most safety sales must be made on an individual basis by a salesman who studies his prospect carefully, learns all he can about him, gets him to talk, and guides his thinking along the path that will lead to the sale. He seeks to find out what his prospect's wants and desires are, what things look valuable to him, and he presents his product in a way to prove that its possession will minister to the need or desire or want that it fits.

The three steps in a sale

It is well to point out that there are at least three steps to every sale. (Some sales authorities will insist on more, but three are

basic.) These three steps are the *preparation*, the *presentation*, and the *close*.

The *preparation* means (very briefly) getting all possibly helpful information about the prospect, matching it up against the values of the product, and deciding which value or values to use in the presentation—what desires or needs to appeal to. For example, a toolmaker who did not want to wear goggles on some grinding work was found to be an amateur biologist. He had built his own microscope and spent most of his evenings over it. The successful appeal then was the fact that even fine pieces from the grinding could easily cause opacity with resultant damage to vision.

The foregoing example is illustrative of what to present but not of how to present it. The *presentation* might be made as follows. The toolmaker of the example was an elderly man of long experience, who, however, had not had much experience with the type of grinding in question. Further, he greatly valued fine technical skill; and since neither the foreman nor the safety engineer were possessors of such skill, he did not have much respect for their opinions. But the physician whom the company retained to supervise its first-aid setup was a surgeon of great skill whom the toolmaker liked and respected. The physician's help was enlisted by the safety engineer who brought him out to the job and, with the foreman, showed and explained to him in detail the whole operation. After the physician had satisfied himself that there was a hazard, he told the toolmaker just what the fine flying particles could do to his eyesight. The point was won.

Two things are important in the *close*, the timing and the commitment. If a salesman could be a mind reader, he would press for the commitment the moment he read the thought "I want that"; but it isn't as easy as that. The salesman must judge the proper moment from his prospect's speech and manner, but mainly from what he says. Therefore, the salesman who talks too much misses clues, and the salesman who talks too little loses control of the sale.

No sale is complete without a commitment verbally or in writing to someone on something definite. The toolmaker committed himself by saying to the physician, "All right, Doctor, I didn't see it that way. I guess you are right. I can't afford to damage my eyes. I'll wear the goggles." And the safety engineer further clinched the matter by asking the toolmaker, "Would you like to have Dr. Blank (the oculist) fit your goggles? He might want to test your eyes to see if you need prescription lenses in the goggles. I'll make an appointment if you wish." The acceptance of that invitation made a withdrawal practically impossible.

No new selling point should be brought out after the commitment is made. Selling should stop and some form of commendation is in order if only "I'm glad you see it that way, John. The fact that you do will help me get others to protect their eyesight." On the other hand, bringing in some new idea may upset the sale, because it may run counter to some strongly fixed prejudice the prospect may have.

To whom must safety be sold?

The answer is, literally safety must be sold to everyone in an organization: the management, particularly the top operating executive, because he must furnish the executive leadership without which the safety effort won't get far; the supervisory staff, because its members carry out the will and policies of the management; the workmen, because they do the work that brings them into contact with the hazards.

Selling the management

A major purpose of this book is to furnish information that will help to convince managements that they should be satisfied with nothing less than best possible safety performance. The chapters "Accident Costs" and "Plant Inspection" should be particularly valuable to this end. However, as previously pointed out, if executive interest is lacking, the first and vital problem the safety man must solve is the stimulation of that interest to the point of effective action. He will probably have to convince the executive of three things:

1. That the accident record of the establishment is not good enough.
2. That other managements have found that good safety performance pays.
3. That good safety performance can be had by an effort the management can reasonably make.

The details of how these three points can best be won in each instance must of necessity be developed to suit the characteristics of the executive in question and the facts of the situation.

Selling the supervisory staff

The key to selling the supervisory staff lies in the simple fact that any person who values his job tries hardest to accomplish whatever it is that his boss appears to want most. If the boss is sold on safety and makes it clear that it is really one of his chief

wants, his foremen will undertake to get it for him. And they will keep up their effort just as long as he keeps on wanting it. But if he transfers his interest to something else, their major effort will follow the path in which his interest is keenest and safety will suffer. As long as the top executive maintains his interest in production, cost, and quality, his staff keeps on trying to improve them. If he adds safety to this "sacred three," they will, also. So, selling the foreman on safety is primarily the chief's job; but the safety man can help mightily. He can furnish information and ideas and the safety viewpoint for his chief to use. If the boss wants safety, any source from which help may be had will be welcome. If the safety man knows his "stuff," his advice will be heeded and his help will be welcomed. But if the boss doesn't evidence much interest in safety, the safety man has the hardest of all selling jobs in trying to sell the foremen something that their boss quite evidently doesn't think much of.

Selling the workmen

The foreman is the key man here just as he is in production, but the safety man has a vital part, too. He is the technician of safety, the planner, the organizer, the stimulator. He works with and through the foremen, helping each do the safety job in his field of action. He continually watches the safety work of the whole organization, keeps his chief in touch, and directly, or through the chief, applies corrective pressure wherever improvement is needed. The foreman develops safety-mindedness and promotes safe practice in his men by knowing the work and by a process of finding out each man's abilities and habits and characteristics. He endeavors to direct and lead each man along the lines that will best promote his interest in his work and contribute to his pride in doing good work, his satisfaction in his work, and his liking for the job. Men do well at work they like, and poorly at work they dislike. They like what they can do well. They soon come to dislike what they have little aptitude for.

The organized safety sales program

The individual personalized work of the foreman in promoting the safe practice of his men should be supplemented by a definite organized safety sales program. This is a primary responsibility of the safety man. It is a combination of advertising, information giving, and the promotion of worker participation in the accident-prevention program. While, as pointed out, the foreman is the key safety man, he needs all possible help. A soundly conceived and properly prosecuted safety program will be of great aid to the

foremen in improving safe practice just as a sound advertising program aids the commercial sales force to get orders, even though it may bring in relatively few orders of itself.

This general program is directed at the major motivating characteristics that men have. Psychologists in listing these differ somewhat in the descriptive terms used and in the prominence they give the respective characteristics, traits, desires, or incentives. However, there seems to be pretty general agreement that the following can be effectively appealed to through an organized promotional safety program:

1. Instinct of self-preservation.
2. Desire for material gain.
3. Desire for praise, approbation, or distinction.
4. Fear of ridicule or disapproval.
5. Sense of humanity.
6. Sense of responsibility.
7. Sense of loyalty.
8. Competitive instinct.
9. Desire for power or leadership.

Note that the first of these is probably the strongest motivating characteristic in all forms of intelligent life. Civilized man tends to elevate motives he regards as nobler; but since this instinct is so deeply rooted in all of us, it will, if properly appealed to, prove powerfully stimulative of safe practice. Care must be used in shaping the appeal, but the same may be said of appeals aimed at any of the other motivating characteristics. It is after all merely another phase of the third essential of salesmanship, namely the appeal must be so fashioned as to be attractive to or otherwise effective with the prospect. The salesman does this by studying each prospect as an individual and shaping his appeal accordingly; the advertising salesman shapes each appeal to reach a characteristic or desire that all or nearly all men have in greater or less degree. He knows that no one appeal will reach all; but by varying the appeals aimed at each such characteristic, and by aiming several appeals at each of them, he expects to "score an occasional effective hit" on every man (or woman) in the entire working force.

For emphasis, a point already made is again presented, namely, that most men are influenced (perhaps *pushed* is a better word) into safety-mindedness by a process of selling on an individual basis; that is, through definite training courses, by the personalized training and supervision the foreman carries on, and by taking part in such safety activities as committee work or accident investi-

gation, under the proper leadership. The organized safety sales program makes few direct sales of safety, but properly set up and maintained, it aids, strengthens, and stimulates the direct sales work greatly.

Infinite ingenuity has been used in reaching the various motivating characteristics, and successful methods have been reported in almost endless detail. A few deserve special mention.

Instinct of self-preservation. Feature injuries from typical unsafe practices in a manner to emphasize the possibility of death or the consequences of losing an eye, suffering an amputation, or losing the use of a member. Few people realize how good life is until they face the prospect of losing it. They take the life-long possession of all body members and faculties in full working order for granted.

The presentation must fit; there is little value in depicting the danger of losing an eye unless an eye hazard has been shown to exist; safety shoes have little appeal to anyone unless it can be shown that his foot is likely to be in position to be caught; a man who has operated woodworking machines for many years and has all his fingers is likely to cite that fact as proof that it "won't happen to him." He doesn't realize that one finger is too many to lose in a lifetime and that, unless he always follows safe practice, the law of averages will almost surely "catch up with him" eventually.

Example. Workman who is lax in wearing goggles. Offer to sell him a glass eye or send him to the nurse to have a patch put over one eye for an hour or two.

Desire for gain. Offer rewards in pay, bonuses, cash, prizes, objects of value for good safety performance or safety suggestions. The rewards should have a reasonable relationship to the effort involved and be large enough to be attractive. Absolute fairness must be the rule. Favoritism will quickly nullify all value of this method.

Example. A dollar or two each month for each workman who goes through the month without a lost-time injury. A specific system of cash awards ranging from $5 to $100 for safety ideas.

Desire for praise, approbation, or distinction. Persons in whom this trait is strong respond to awards of badges, honor dinners, public mention, personal letters of commendation from an outstanding person, such as the president of the company or a respected public official.

Fear of ridicule or disapproval. Practically every person is sensitive to the disapproval of his fellows, particularly those whom he likes, but great care must be exercised if this fact is to be made

use of. Ridicule is a dangerous weapon; for unless it is very skillfully used, it is likely to induce defiant or emotional behavior that will harm rather than help safety. However, safety performance can often be improved by making it evident that continued faulty performance will bring disapproval.

Example. When departments or crews are striving for the longest no-accident period, a workman discovered violating safe practice will often correct his behavior when his fellows voice their disapproval or even if it is merely pointed out that an accident would bring disapproval.

Sense of humanity. No one wants to see anyone hurt. All normal people are moved by suffering. So the slogan "Watch Yourself" is the workshop expression of the fact that to some extent and under some circumstances each of us will undertake to be "our brother's keeper." As one man put it, "I figure I owe it to myself to keep him from getting hurt if I see he is in danger." So the wise safety man encourages this attitude in a matter-of-course way and at every opportunity. He does not question that all men are humane; he merely seeks to bring the instinct out and make it more active.

Sense of responsibility. Every person feels some degree of responsibility for something. Few people will deliberately fail to try if they know that others depend on them to perform in a specified manner. Assigning one the responsibility to do something and then giving generous (but not false) credit for satisfactory performance combines the force of this trait with the desire for praise.

Examples. Assigning to a certain mechanic the duty of keeping the abrasive wheels in safe operating condition and noting with favorable comment a particularly good overhaul job he does on one of them. Assigning specific cleaning duties to a janitor, asking him for suggestions as to how to prevent disorder and dirt, and praising his good performance.

Sense of loyalty. A man is loyal to his country, to a kindly foreman, to his union, his club, his lodge, his friends, his family. The advertising program, therefore, will direct appeals to these loyalties, but each appeal should have some reasonable relationship to the situation. In war, the plea to support the men at the front can be made strong. In peace, the emergency feature is lacking, but it can still be shown that one should be loyal to the standards set by his associates, his leader, or his company.

Competitive instinct. Most people love competition in some form. Safety contests rest on this trait. To be effective, the "rules of the game" must be clear, the contest must be a reasonable one, and the issue must be decided fairly. Accident contests are discussed in a preceding chapter, but it is pointed out here that a

form of cheating—bringing injured workers back to practically workless jobs that have been created for the purpose—has brought such widespread criticism as largely to nullify the value of such contests.

Desire for power or leadership. This can frequently be made use of by appointment to safety committees or to office in safety organizations, to lead safety rallies, to preside at safety meetings, or to positions of special distinction, such as safety monitors, minute men, and so on.

Plant advertising media

The following advertising media are commonly used:

1. Posters.
2. Large plant bulletin boards.
3. Plant newspapers.
4. Messages in pay envelopes.
5. Display of interesting objects.
6. Signs and slogans.

Posters. Promoting safety interest by the use of posters was one of the first projects undertaken by the National Safety Council. The Council offers posters as a membership service in unending variety. They have proved to have a continuing value. Styles in posters change just as styles in clothing and furniture do. Treatment and presentation change also. Posters must keep up with the times, and their messages must be in accord with current conditions, current events, and trends of thought. They must draw the attention of those at whom their messages are directed. They must stimulate their thought processes, impel them toward the desired type of action or form of conduct or behavior.

Pictures speak a universal language. Everyone can read a picture couched in familiar terms. The easiest and quickest avenue of learning is through the eyes. A picture that conveys a clear message, transmits an idea in a fraction of the time and more clearly than can be done by writing. However, picturization is obviously limited to simple ideas and impressions and, therefore, can at best be merely one of the several valuable means of stimulating safety interest and safety practice.

Much depends upon the presentation. The idea must be clear; the setup must fit the idea. Color can fascinate or it can repel. Figures can attract by their naturalness or by clever exaggeration or cartooning. Attractiveness is of major importance.

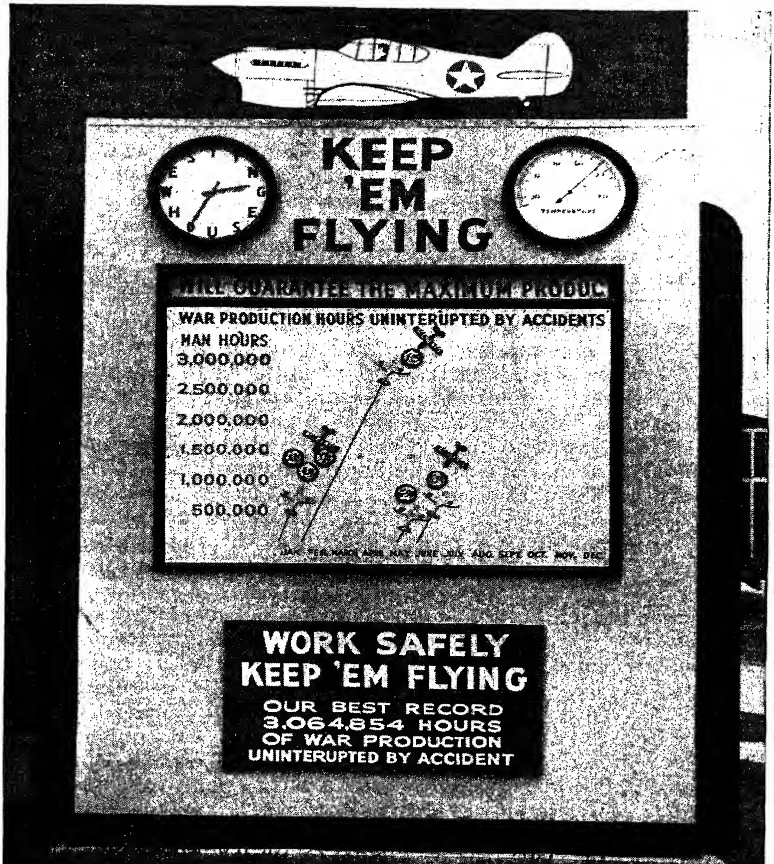
Posters should be used liberally, but not in overabundance. A few at a time, in locations where each will attract attention, with frequent enough changing to avoid staleness, are much more effec-

tive than an accumulation. A given idea is driven home better by a series of posters successively displayed than by the same posters displayed at the same time. They are more effective posted on neat bulletin boards than just posted. Bulletin boards should be well made, attractive, and well finished and maintained. The material on them should be orderly. There is difference of opinion as to whether or not it is best to have specific boards solely for safety material. There should be no stale material, however, particularly announcements kept past the dates with which they deal. Bulletin board locations should be carefully selected and then kept. Posters should be securely mounted, protected from soiling, and, if outside, from the weather. Lighting should be good. Posters are best seen above eye level; but whatever the location, wording if any must be readily readable from a convenient position. One bulletin board or one poster of a kind for 100 employees is a good ratio in general, though it can well vary to accord reasonably with the density of plant population.

The large outside plant bulletin board. To furnish a continuing picture of the accident record and to stimulate rivalry between different plants or departments, many plants set up large boards at the plant gate or other favorable location. It is advantageous to include some feature to draw attention, such as a clock, indicating thermometer, wind gauge, or drinking fountain, and, of course, the accident score up to date. The board in the illustration on page 245 is at the East Springfield plant of the Westinghouse Electric and Manufacturing Company. The moving tape below the clock and thermometer carries a safety message in red and green. The small silver planes continue to climb until an accident occurs, which is designated by a black dive bomber. Each round piece represents an accident. It carries the departmental designation in which the accident occurred and is painted to resemble an explosion. The main part of the board is pearl gray with a bright red border, and the placque at the bottom is deep blue with white lettering.

Plant newspapers. These are a well-established and valuable medium for the building of plant morale, provided they are newsy, interesting, and suitably written. Safety can advantageously be given a large part in them. It is essential that the safety messages be timely, pertinent to plant conditions, practical, and carefully written. If the responsible safety head is not the editor, there should be at least very close coöperation between him and the editor. A column featuring safety suggestions from workmen and the action on such suggestions can be a particularly valuable feature, provided the action on the suggestions actually is good.

Messages in pay envelopes. Used in moderation and couched in a spirit of helpfulness rather than one of command, such messages have considerable effectiveness. Information on off-the-job



Courtesy Westinghouse Electric & Mfg. Co.

A large yard bulletin board.

and home safety can well be given in this way. Also, announcements of special bonuses, awards or prizes, plant outings, and so on, are often made in this manner.

Display of interesting objects. Great interest can often be aroused by displaying something that has been a contributing factor in causing or preventing an accident. For instance, a tool with a mushroomed head, broken goggles, a battered safety shoe, may be displayed, each with its descriptive short but clear story including the name or better yet the picture of the victim or near victim. Samples of defects caught by inspection or someone's vigilance make excellent displays, as a piece of acid-eaten manila rope contrasted with an undamaged piece, a loaded sprinkler head contrasted with a clean one, a worn extension cord, a wrench with sprung jaws, and the like. Also, specific information may be given, as a properly tied square knot contrasted with a granny knot, or the construction of wire cables. Such displays should be kept clean and free from dust; and while they will not get stale as quickly as posters do, they should be changed when they have been up a reasonable length of time.

Signs and slogans. Properly used, these have considerable value both in giving safety information and in promoting safety interest. Signs should be truthful, definite as to meaning, and in correct English. For instance, a sign that says "High Voltage" should be used only for voltages that standard practice considers high. Where a warning as to the location of electrical equipment carrying low voltages is desirable, some such wording as "Danger—Live Voltages" should be used.

All safety signs should be carefully located to be visible to any person approaching the position of hazard. Signs should be neat, well made, and finished, durable for the conditions involved, and kept clean and in good condition.

Slogans can be very valuable, but they must express a worthwhile purpose or goal and they must be timely. Furthermore, the management must itself show by its actions that it believes in them and is earnestly trying to live up to them. An outstanding example is the much used, often abused, and much discussed "Safety First." If the management really means it and shows its belief by convincing action, this slogan should be posted proudly and kept bright; but posting it everywhere in a plant full of hazards within the power of the management to correct makes a travesty of it, and it is better not to use the term at all.

For detailed suggestions as to the construction lettering, and so on, of signs, see "American Standard" Specifications for Industrial Accident Prevention Signs.

Employee participation

In general, the greater the employee participation in the safety program, the more effective it will be. Therefore, the organized

safety program should include as many activities in which workmen can take a part as possible; and further, it should give them the major roles whenever and wherever possible. Such activities include:

1. Safety campaigns and contests.
2. Safety meetings and safety stunts.
3. First-aid training.
4. Plant fire brigades.
5. Plant inspection.
6. Accident investigation.
7. Job safety analyses.
8. Safety suggestion systems.
9. Safety inventories.
10. Safety committees (safety organization).

Most of these activities are dealt with in other chapters. Detailed information on the remainder will be found in applicable Safe Practices pamphlets or in current safety literature or both. However, a few comments are justified here.

Safety campaigns. The value of occasional safety campaigns has been much discussed. Such campaigns are of undoubted value if properly timed and properly conducted. They are timely when a special situation arises that calls for a general quickening of safety interest, for example, general laxity in wearing goggles, a general staleness in the safety work, a seeming epidemic of unsafe practices or a run of accidents. To be effective, a campaign must be more than a rehashing of "old stuff." There must be an element of newness, variation in presentation, new faces in major roles, new assignments of responsibilities, a freshening and intensification of effort. Good planning and good leadership are required, a definite program set up and followed, a definite goal set, and a definite period specified. The major drawback of such a campaign is that after it is over there is a letdown. However, every campaign that measurably attains a worth-while goal will have scored thereby some lasting gains, and even the letdown that follows will usually still represent an advance over the conditions that preceded the campaign.

Similar comments apply to contests, with emphasis, however, on the importance of having definite, clear, equitable rules and of "playing the game fairly" in all respects.

Safety meetings and safety stunts. Safety meetings are standard practice in establishments whose safety performance is good or superior. They are routine in production, and adding

safety is merely a step in the incorporation of safety into all phases of plant activity. Some managements include safety intimately in routine staff or personnel meetings; others hold separate meetings. Some have meetings weekly or even oftener. Others have bi-monthly or monthly meetings. Some have regular safety meetings for supervisory personnel, but leave it to each foreman to have meetings of his crew when he feels the need. Others schedule such meetings regularly. Almost any such system works well, provided that it has the essential element of executive interest and supervision. Without that, no system will work well.

Extra meetings outside of working time are often helpful if the element of entertainment is sufficiently included or if they can be merged with some community or group interest or activity as church, school, athletic club, and so on.

Plant fire brigades. The responsibility, the distinction, and the chance of excitement make membership on a plant fire-fighting and fire-prevention brigade attractive to most men. Membership can be largely rotational. Much as is the case with first-aid training, such participation is strongly stimulative of safety-mindedness.

Safety suggestion systems. Every management should realize that the aggregate brain power and resourcefulness of its rank-and-file workmen is a veritable gold mine of ideas if it can be tapped. A properly designed and administered suggestion system is an effective means of tapping this latent safety knowledge and ingenuity. Essential to its successful operation are:

1. The management must really want suggestions from its workmen.
2. Every suggestion must be taken seriously and, if it is not usable, an explanation must be made to its author as to why it is not.
3. Action in each instance should be prompt or the reason for any necessary delay explained.
4. Anonymity should be respected if desired by the maker of the suggestion.
5. Rewards should be in reasonable relation to the value of the suggestion.
6. If the plant is organized, the coöperation of the union should be sought.

While by no means all suggestion systems have proved to be of value, the general experience when the foregoing essentials are reasonably complied with appears to have been very favorable indeed.

Safety cartoons. Cartoons showing bad practice and bad conditions are being increasingly used because of their effective-

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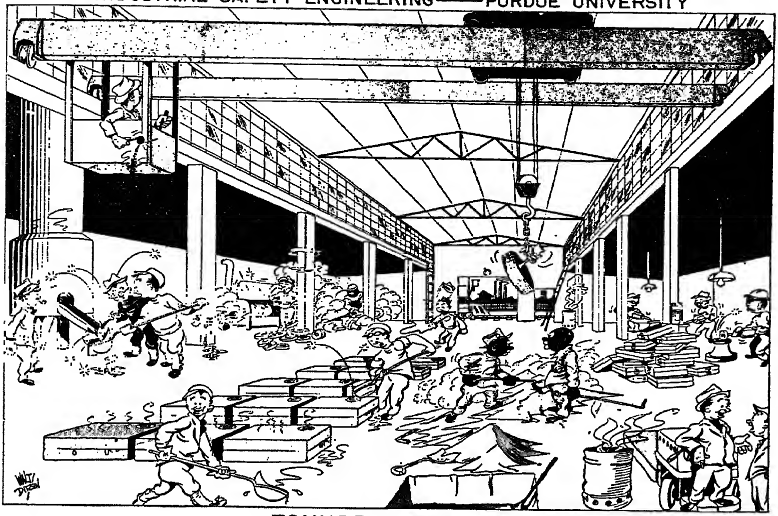
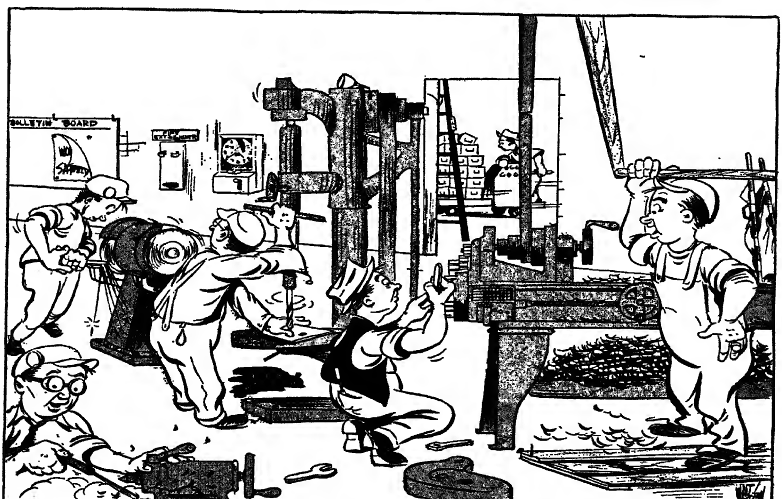


FOUNDRY HAZARDS



UNSAFE MACHINE SHOP PRACTICES

Courtesy of Purdue Uni

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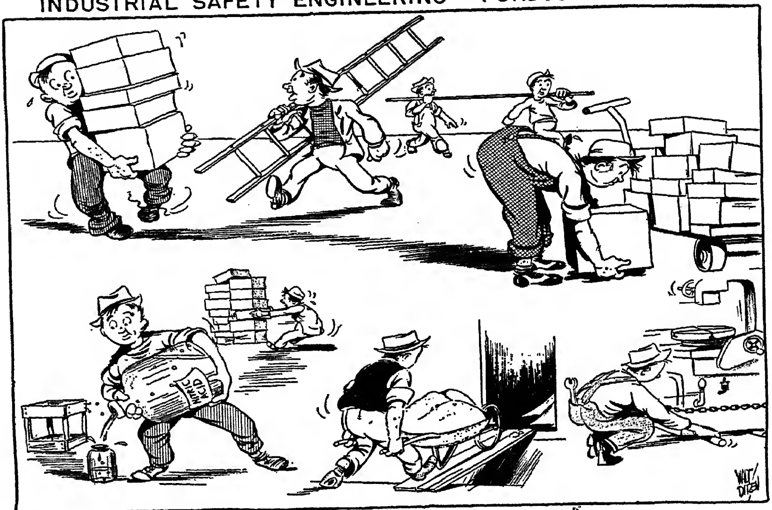
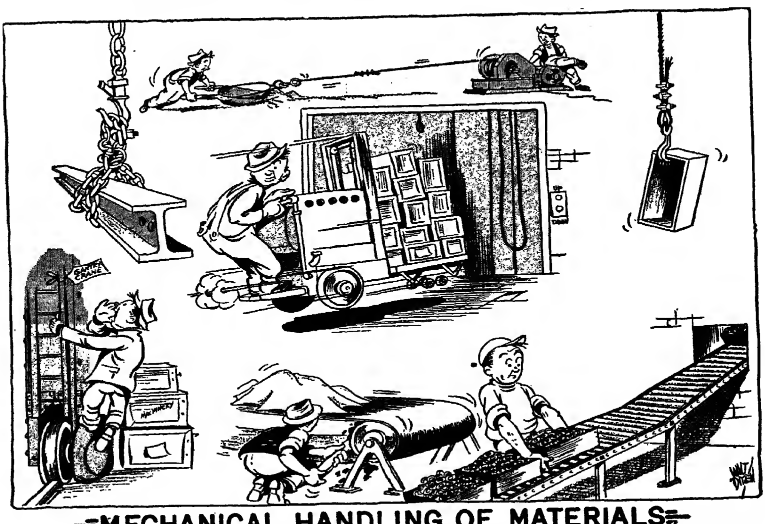


MANUAL HANDLING OF MATERIALS



MECHANICAL HANDLING OF MATERIALS

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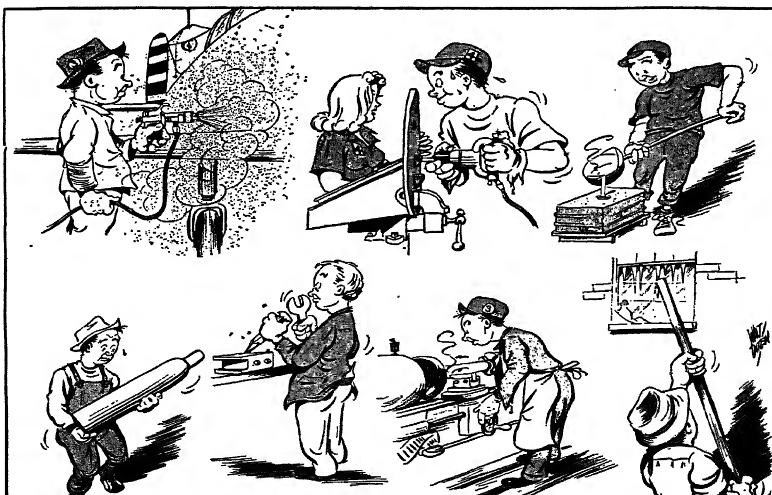
—ELECTRICAL EQUIPMENT HAZARDS—



—PROTECTIVE EQUIPMENT—

Courtesy of Purdue University.

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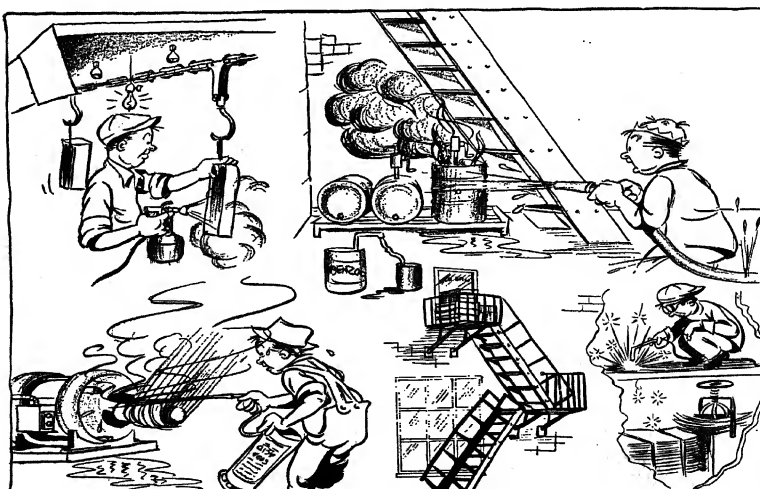
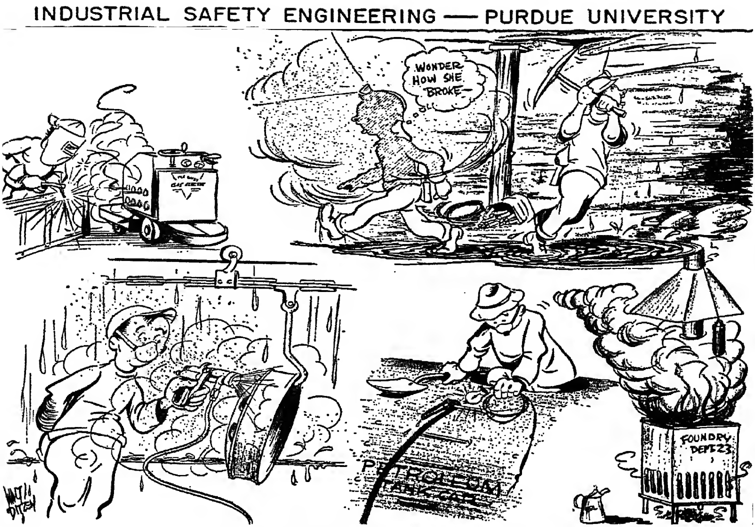
"WORST" AID



FIRE HAZARDS

Courtesy of Purdue University.



HEALTH HAZARDS

Courtesy of Purdue University.

ness in promoting interest in safety. They appeal to the same side of human nature that IQ tests and cross-word puzzles do. Samples of some cartoons developed by Purdue University are reproduced here.

REVIEW

1. Why must at least reasonable attention to physical hazards precede a program to promote employee safe practice?

2. When should the use of slogan "Safety First" be avoided?

3. What legitimate criticism has been made of safety contests generally?

4. Why must safe practice be sold to men rather than demanded of them as a duty of their employment?

5. Why is the foreman the key safety man?

6. Name the three essentials of a sound sale.

7. Name the three basic steps of a sale.

8. What is necessary to complete a sale?

9. What is the essential difference between the selling method the foreman uses and that used by the safety director in developing his safety promotional program?

10. Name what you regard as the five safety activities most valuable in giving workmen an active part in the safety program, and state briefly why you select each of these.

CHAPTER XXIII

The Safety Inventory

A problem that faces the safety director constantly is that of finding out what the employees really think of the safety program and just how interested they are in it. The safety inventory, properly conducted in a plant in which the attitude of the management has been such as to favor an honest response, will furnish effective help toward a solution of the problem by giving answers to such questions as the following:

1. Would the employees, if they were given their choice, take part in the safety program?
2. Are they tired of the word "safety"?
3. Is the program of educational posters, meetings, and so on, just another "one of those things"?

Safety inventories were started at the East Springfield Plant of Westinghouse in the year 1937. Since that time, such inventories have become a standard practice in this plant. Through this medium, the employees' attitudes toward safety have been ascertained each year, and, with employee approval and coöperation, the following year's safety program has been planned. Through these inventories, many suggestions for improvement of the safety program have been received and put into practice.

Immediately on return to work after the plant's regular stock inventory, safety inventory cards are distributed to each employee, from sweeper to engineer, and to the salaried workers as well as workers who are paid by the hour. The cards are distributed by foremen or supervisors, with the request that each employee take stock of his job and environment with regard to safety. Although the questions are designed to discover unsafe conditions, to create interest and develop safety consciousness, to educate the employee in safe practices, they deal also with the positive, or health side of the safety program.

SAFETY INVENTORY AT THE EAST SPRINGFIELD WESTINGHOUSE PLANT

For the safety inventory herein cited, 2,025 cards were distributed upon return to work after the plant's regular stock inventory had been made. Of these—

1,625 were distributed among hourly paid employees.
1,544 of these were returned completely filled out.
400 were distributed among salaried and office workers.
360 of these were returned completely filled out.

Question. "Why should cards be distributed to office and salaried workers?"

Answers. Everyone must feel and know that all are interested in the safety program—the office worker as well as the shop worker; management as well as employees. Carefulness is just as necessary for those walking around the office, going up and down stairs, handling a ditto or mimeographing machine, as it is for those handling a light punch press or lathe, or driving an electric truck in the plant.

Question. "Is your equipment properly guarded?"

Answers. "Yes," 1,080. "No," 26.

In asking this question, the safety committee wanted to know how the employees felt about their equipment, believing that if the employees had an opportunity to express themselves freely there was more likelihood that they would coöperate in using it safely. In the 26 "No's" the safety committee had an immediate job of investigation and recommendation to perform.

Question. "What kind of safety device is used on your equipment?"

Answers. "Guards over belts to protect me." "Hand trips to protect my fingers." "Switch interlocks." "Safety shields to protect my eyes."

The intent of this question was to interest the employee in the type of equipment used, as well as the why of its use.

Question. "What improvements do you recommend?"

Answers. Ninety-six suggestions were received in answer to this question. Eighteen suggested a new type of safety equipment, and 78 asked for miscellaneous improvements, including better lighting facilities and better ventilation.

Question. "Where is the nearest fire-alarm box?" "Where is the nearest stretcher?"

These two questions were very interesting and caused considerable commotion throughout the plant. Everyone was asking them of everyone else. The reactions to the questions indicated how little people know about the commonplace things that are so necessary when needed. It is recommended that just as the steamship captain requires fire drill periodically to keep his crew and passengers alert for an emergency, so these questions should be asked periodically to keep employees posted as to the whereabouts of such equipment.

HEALTH & SAFETY INVENTORY
WESTINGHOUSE FORM 21780

Please read the inventory instructions carefully before filling in this card

Dept.................Group.................Occupation.................

1. Do you operate a machine?.........Is it properly guarded?.........Recommendations.................
2. What personal safety equipment do you use on your job?.................
....
3. What additional personal safety equipment do you require?.................
4. Do you wear safety shoes at work?.........If not, why?.................
5. Have you completed a course in First Aid?.........When?.........With whom?.................
6. Would you be interested in attending First Aid classes this winter?.................
7. Would you be interested in attending classes in Home, Highway, and Industrial Safety this winter?.................
8. Did you use salt tablets this summer?.........Please comment on them.................
9. How much time did you lose this year because of sickness?.........Home accidents?.................
Automobile accidents?.........Other accidents (explain).................
10. When were you last examined by a doctor?.........Do you want a physical examination?.................
11. Have you any additional recommendations for the advancement of safety and health among our employes?.................

.... SIGNED.................
Name · Date

USE OTHER SIDE FOR ADDITIONAL COMMENTS

Courtesy Westinghouse Electric & Mfg. Co.

Safety Inventory Card 1937.

Question. "What personal safety equipment do you use?"

This question was designed to call the attention of the employee to the extent of management's interest in his welfare when on the job. Too often equipment such as aprons, gloves, tweezers, and so on, is issued out of stock without any thought on the part of the employee that they are purchased for him and issued to him by the company for his health and safety. The tabulation brought out the following facts about materials purchased for the protection of the employees:

170 aprons	Fireproof duck for welders and solderers; rubber aprons for acid dippers and platers and any operations where there is dampness or wet processing
63 pairs gauntlets	For welders and platers
587 pairs gloves	Cotton or leather; palms for material handlers, laborers, hand winders, and women operators in certain operations. Leather gloves for welders and rubber gloves for platers and acid dippers
391 pairs goggles	All types for all operations where there is possibility of eye hazard—machine operators, grinders, welders, certain foundry operations, etc.
46 pairs leggings	For certain foundry and plating operations
26 respirators	For foundry shakeout crews, spray painters, and certain dust-producing operations
66 pairs tweezers	For punch press operators
31 welding masks	For acetylene and atomic hydrogen welders

Question. "Do you use hand cream to protect your hands and arms?"

Protex is furnished by the company on all occupations where the employee comes in contact with cutting compounds. It is a preventive against dermatitis. It is expensive, consequently it is used only where exposure occurs.

Question. "How extensively is hand cream used and by whom?"

Employees to the number of 254 stated that they were using it all the time, on such occupations as hand and automatic screw machines, certain lathe operations, wash tanks, painters, platers, acid dippers, and so on.

Question. What additional personal equipment should be furnished to safeguard you on your job?

Suggestions to the number of 111 were received as to additional personal safety equipment desired. Maintenance workers wanted more fuse pullers; others wanted more goggles, gloves, safety feet for ladders, a hoist, a fire extinguisher, a blower; and one suggestion was made to build a truck the same height as the presses for easier handling of dies into the press.

Question. "Do you wear safety shoes? If not, why not?"

Answers. "Yes," 215. "No," 763.

1938 Safety Inventory

Westinghouse Electric & Mfg. Co. East Springfield Works

Please read the inventory instructions carefully before filling in this card

JD 4
65
017 01 8677
4 THORMEYER F

Division .... Department .... Group .... Occupation ....

1 Equipment used by you .... Machine No. .... (Brass tag only)

2 Is the equipment properly guarded? .... 3 Kind of safety device used ....

4 What safety improvements do you recommend? ....

5 Where is the nearest fire alarm box? .... Box No. .... 6 Where is the nearest stretcher? ....

7 Check off the personal safety equipment that you use Aprons (Rubber or Asbestos) .... Gauntlets .... Gloves ....
Goggles .... Leggings .... Respirators .... Tweezers .... Welding Masks ....

8 Do you use Protex (hand cream) to protect your hands or arms? ....

9 What additional personal safety equipment should be used on your job? ....

10 Men—Do you wear safety shoes at work? .... If not, why not? ....
Women—Do you wear Low or Cuban type heel shoes at work? .... If not, why not? ....

11 When working, do you wear Finger rings? .... Arm bracelets? .... Long sleeves? ....

12 Does your work make you nervous or over-fatigued? ....

Continued on other side

13 Are there any physical ill effects from your work? ....

14 Does your job require you to Stand? .... Sit? .... Walk around? ....

15 Do you know the company safety rules? ....16 Do you believe the safety rules should be enforced? ....

17 Are the company safety rules for your benefit? .... for the company's benefit? .... or for the benefit of both? ....

18 What can be done to improve your working conditions in regard to health and safety? ....

....

19 Have you ever completed a course in First Aid? .... When? ....

20 Would you be interested in attending classes in First Aid, this winter? ....

21 Would you be interested in attending classes in Home, Highway and Industrial Safety, this winter? ....

22 Have you any other suggestions for the advancement of safety in this Plant? ....

....

....

Signed ....

Employee Group Leader Safety Representative Foreman

Courtesy Westinghouse Electric & Mfg. Co.

Reverse side of 1938 inventory.

Answers to this question were varied and indicated in many cases that a selling job was still to be done in this field. Many of the employees had had sad experiences in the past with safety shoes and as a result were reluctant to try them again. Others stated that safety shoes weren't needed on their jobs.

Question. "Do you wear low or cuban heels at work?"

Answers. Number of women asked, 383. "Yes," 198. "No," 14.

Question. "When working, do you wear finger rings, arm bracelets, long sleeves?"

Such practice is particularly hazardous on operations of machinery such as drill presses, lathes, and so on, where work rotates and there is the possibility of the ring or sleeve getting caught in the rotating work. The practice results in some of the most serious accidents recorded by many firms.

(The intent of these two questions was to point out to women that on certain occupations the wearing of high heels, finger rings, bracelets, and long sleeves is hazardous.)

Question. "Does your work make you nervous or overfatigued?"

Answers. "Yes," 75. "Sometimes," 7.

It was found that many accidents were due to nervousness or overfatigue. New help anxious to make good on the job; older employees transferred from one job to another, oftentimes to a heavier or a faster job; the physical condition of the individual; a worker placed on the wrong job—all of these were factors that merited the attention of a real, live, safety committee.

Question. "Do you experience any physical ill effects from your work?"

Answers. "Yes," 84. "No," 1,538.

All of the 84 answering positively gave reasons for their complaints—fumes, vapors, drafts, and so on. The management investigated and corrected the causes, even to the extent of calling in a chemist to analyze the jobs where complaints had stated "fumes and vapors."

Question. "Does your job require you to stand? Sit? Walk around?"

This question of course ties in with the one asked about fatigue and may even have been the cause in many cases. All cases were investigated by the Safety Committee, as a part of the safety program for the year. A chair designed especially for women workers was the result of one investigation.

Question. "Do you know the company's safety rules?"

Answers. "Yes," 1,409. "No," 74.

Needless to say, the 74 No's soon found out. Each was called on by a member of the Safety Committee, the rules were explained, and a copy was left with the worker.

Question. "Do you believe that the safety rules should be enforced?"

Answers. "Yes," 1,950. "No," 74.

The answers received to this question were very gratifying to the committee, for they indicated that the average employee is still rather sensible about his own welfare and that of others around him. He will stand for no tomfoolery about safety, and he doesn't hesitate to state so when given the opportunity to express himself.

Question. "Are the company safety rules for your benefit? For the Company's? Or for both?"

Answers. "Yours," 1500. "The Company's," 100. "Both," 1,800.

This tabulation indicated that most employees felt that the company safety rules benefited both the company and the employee and stated so in both places on the card.

Question. "What can be done to improve your working conditions with regard to your health and safety?"

Answers. Here was an opportunity for all to suggest improvements if they so desired. Suggestions were received to the number of 381, including suggestions for the elimination of drafts, better lighting, ventilation, new safety devices, and so on.

The Safety Committee was anxious to get an expression of the feelings of the employees about first-aid courses and whether they would take part in such courses if they were offered.

Question. "Have you ever completed a first-aid course?"

Answers. Two hundred and forty-three employees stated that they had completed a first-aid course at some time or other. The majority of those who had completed such a course stated that they had gained their knowledge in the Boy Scouts of America; the next largest group, in the Army. Others stated that they had received their knowledge from former employers, schools, colleges, Red Cross, and so on.

Question. "Would you be interested in attending classes in first aid?"

Answers. "Yes," 660.

Classes were formed immediately, but because of a dearth of

instructors it was necessary to limit the number of enrollments to 145, who met each week for a period of ten weeks, 100 of them finally receiving diplomas at the annual meeting of the local Red Cross chapter.

These first-aid classes are being continued, for the Westinghouse Plant believes it good policy to have on hand and available throughout the works men and women capable and trained to do a good first-aid job when and if the emergency arises. The classes in 1943 were built up to cover a wider field than ever before. Standard first-aid classes were arranged for those who had no first-aid training. Advanced first-aid classes were scheduled for those who had completed the standard course. In addition to this, arrangements were made for some of those best qualified to attend an instructors' course so that the plant would possess its own first-aid instructors. In this way it was made possible to carry on from year to year a series of courses in first-aid instruction.

The following question also indicated an interest in all phases of safety among the employees.

Question. "Would you be interested in attending classes in home, highway, and industrial safety?"

Answers. "Yes," 487.

In the 1939 Health and Safety Inventory, many of the questions, as those above, were duplicated for comparison and to check the work of the Safety Committee. Most interesting in the comparison was the question with reference to the wearing of safety shoes, indicating definitely that the Committee had been on the job.

Question. "Do you wear safety shoes?"

Answers. In 1938, 215 had answered "Yes." In 1939, 335 answered "Yes." The increase was 120.

During the summer of 1942, salt tablets were distributed quite extensively throughout the Works, and the members of the Safety Committee were interested in knowing the employee's reaction to them.

Question. "Did you use salt tablets this summer?"

Answers. "Yes," 750.

Others commented on them, stating that they had not used them because they did not perspire much and therefore didn't need them. Some said that they had tried them, but had become nauseated, or that they had been made sick by the tablets.

It is obvious that the safety inventory is an excellent tool to measure the effectiveness of the safety job done in the past as well

as to show that there is always room for improvement regardless of how good our records show us to be.

VALUE OF THE SAFETY INVENTORY

The use of the safety inventory at the East Springfield Works of the Westinghouse Electric and Manufacturing Company has been given here in some detail with the thought that this device may be of wide and general value. To those who contemplate using it, the following may be of interest.[1]

As used at East Springfield the value of the safety inventory is unquestioned. It should similarly be valuable in checking on the effectiveness of any well-established and reasonably well-functioning safety program. Good employee coöperation is obviously basic to its success. This coöperation could not be expected in a plant in which at least reasonably good attention had not been given to the elimination of physical hazards. In other words it is, as its name implies, a means of finding flaws, weaknesses, defects, and lacks in performance that is already good.

The use of the safety inventory early in a safety program in order to get the employees' viewpoint and foster their interest is at best highly questionable. It would obviously be more difficult to get good employee coöperation, but, if it were gotten, a flood of recommendations too great to take care of with reasonable promptness would probably result. It would seem to be much sounder to reserve this device for use chiefly as a check up. Most unsafe conditions and hazardous practices are discoverable by plant inspection, job analysis, accident investigation, and cause analysis. Safety committee activities play a large part in this picture. Suggestion systems properly set up and maintained bring in additional valuable ideas and foster further employee coöperation. The safety inventory then supplements all of these things.

A modification of the safety inventory idea has been used early in the safety program by limiting it to safety committee members or other key men. In one plant, after its workmen's safety committees had been functioning for about a year, each committeeman was asked to "inventory" safety conditions in the area he represented. Each used a standard list of common hazards supplemented by one of the hazards peculiar to his area. The results of these inventories were discussed in safety committee meetings and advisable corrective action was decided upon.

Another modification of the idea has been used by labor unions who have issued safety inventory cards (or lists) to members to report on safety conditions in their respective jobs. A particularly notable example of this type of inventory carried out by the Painters' District Council No. 14 of Chicago, Illinois, and published by them in 1935 was a major factor in securing the passage of legislation making occupational disease compensable in that state.

REVIEW

1. Does the safety inventory appeal to you as a worth-while activity?

[1] Condensed from a classroom discussion by R. P. Blake, Senior Safety Engineer, Division of Labor Standards, U. S. Department of Labor, Washington, D. C.

2. Would you attempt it in a plant in which the relationship between employees and management was not good?

3. Would you try it in a plant that was not in a reasonably safe condition?

4. If the plant was organized, would you solicit the coöperation of the union in introducing it?

5. Would you attempt it if the management was not prepared to correct all unsatisfactory conditions disclosed?

CHAPTER XXIV

Safety Organization

The effective production executive knows the value of organization. He realizes fully that no objective can be attained, whether it be for production, inspection, training, selling, or accident prevention without organization, and that an objective of accident prevention or elimination does not "come about" unless all levels of the organization are "tuned in" toward that objective.

Objective organization goes beyond merely the drawing of lines; it attempts to create, first, the lines of authority and flow, and second, the means that will bring about the objective to be attained.

With these principles in mind, we can well appreciate that a reduction in accidents cannot be attained without organization, and that organization itself is without effect unless it has the complete support and interest of "top management."

A recent review of plants indicates many differences in safety organizations and a wide variance of authority and interest from "top management" down through each organization.

A few *musts* should be considered before we discuss specific plans for safety organization:

1. Safety *must* have "top management" approval, sanction, and support.
2. Responsibility for safety *must* rest with the supervisory personnel.
3. Safety *must* be given an equally important consideration with other factors of production.
4. Provision *must* be made for prompt action in the elimination of mechanical and personal hazards.

A definite program should be developed to interest and educate all employees in safety and to secure their active coöperation in the effort to eliminate accidents. Such a program must be based on the full assumption of its responsibilities by the management. The program must supply leadership and executive drive. Safety must be included in all phases of planning, purchasing, supervision, and operation. Once these fundamentals are understood by management, and it fully assumes the responsibilities that are

involved, the appropriate type of organization can be evolved. But it is well to remember that whatever form the organization takes, it will function effectively only if it is backed by executive interest and drive. Proof of this is furnished by the fact that each type of safety organization is to be found among firms that have attained and continue to maintain a standard of first-rate performance in eliminating accidents.

Whatever the size of the firm, the principles and the purpose are identical: "*To create within everyone, at all levels of the organization, a safety consciousness.*"

The flow of consciousness reaching and influencing the minds of those within the organization might well be portrayed as follows:

AREA OF RESPONSIBILITY FOR THE ORGANIZATION	POLICY MAKERS (Top Management) EXECUTIVE (Those responsible for the execution of policy. Superintendents, Staff Heads) SUPERVISORY (Those responsibile for carrying out the policy. Foremen, Group Leaders, etc.) WORKERS (Those who are affected by the policy)

For example, the following might well apply with regard to Safety:

A SAFETY POLICY

Considered and Announced to All for the
Guidance of the Safety Organization
by the
POLICY MAKERS
(Top Management)

SET THE PLAN FOR THE DIRECTION OF THE SAFETY POLICY
by the
EXECUTIVE MANAGEMENT
(Superintendents, Staff Heads)

CARRYING OUT THE PLANS SET FORTH IN THE
POLICY FOR SAFETY
by the
SUPERVISORY MANAGEMENT
(Foremen—Group Leaders—Etc.)

for the

SAFETY OF ALL WITHIN THE ORGANIZATION

From the foregoing it is evident that the major part of safety work and education must be done by the regular organization. We may (making allowances for variations in detail) classify safety organizations in three general types, namely:

A. Those in which the safety work is carried on wholly through the line organization.

B. Those in which the safety work is directed by a safety director reporting to a major executive.

C. Those in which safety work is carried on primarily by committees set up for the purpose.

Type A organization—line organization

Obviously, if no full-time safety personnel—safety technicians—are used, the production executives must become expert in their knowledge of the safety problems involved in their establishment or type of business. The chief executive also must give a larger share of his personal attention to safety than would be the case if he had a highly competent safety technician on his staff. This fact has led some chief executives using this type of safety organization to employ a safety specialist. Such a specialist functions as a technical assistant to the chief executive. Should he possess strong qualities of leadership, he may take over increasing responsibilities for the safety work and bring about a progressive change of the organization into the Type B form.

The strength of the Type A setup lies chiefly in the fact that it centers entire responsibility for all safety effort within each operating unit on the head of that unit. It is his duty to incorporate safety into each and every part of the day-by-day activities of his unit. Just as he plans and supervises the work of each of his men for adequate production and satisfactory quality, so he plans for and supervises safety. He must become the best informed and most safety-minded person in his unit. The weakness of this type of organization is that supervisory personnel occupied with other production problems finds it difficult to acquire the special knowledge needed to reach a high standard of safety performance. This means that too much of the knowledge of how to prevent accidents is gained from the accidents that occur. In other words, it is largely "after-thought" prevention, and, therefore, progress is likely to be slow.

While some large firms use the Type A setup, it is most commonly found among firms too small to justify the employment of a full-time safety engineer. If, in a small plant, the chief executive will really give, and continue to give, a proper share of his executive attention to safety, steady improvement invariably results, leading ultimately to excellent performance.

Type B organization—safety director

The form of organization used by most large firms is of this type. Its effectiveness depends upon two things—the attitude of the top management, and, after that, the competency and ability

of the safety director. While keen interest in safety by top management is essential to first-rate safety performance in any case, nevertheless, a large share of responsibility for the safety work can be delegated to a strong and competent safety director.

A safety director's job is not easy. He should function both as the special assistant and adviser on safety to the major executive and as the adviser and "stimulator" on safety for the whole organization. He cannot interfere with or usurp any of the functions of any member of the supervisory force, but he must work closely with all of them. Since no man can function properly under two bosses, the safety director cannot give orders except to personnel under him, yet he must often secure prompt correction of unsafe conditions or practices. His effectiveness, therefore, will be in direct proportion to:

1. His ability to secure the confidence and respect of every foreman or other executive.
2. The amount of responsibility given him by his "boss."

The safety man must realize that his is a "service" job and that he must not encroach upon the authority of the various members of the supervisory force. His standing with the "boss" will be good if he gets the confidence of the supervisory personnel and if, in addition, he keeps his chief fully informed as to the progress of the safety work. To be effective, the actual means of doing this must suit the personal preferences of the chief. Reports should be brief, definite, and factual.

In brief summation, the safety director must first think of the help he can give each supervisor or other staff man; second, he must try to determine the viewpoint of each so that his help will be well accepted; third, he must be sure of his facts and careful in drawing conclusions; fourth, he must keep the "boss" informed.

Type C organization—safety committees

Safety work governed by committees is usually found in establishments too small to justify a full-time safety director or where by preference the management wishes the work to be directed jointly by the members of his staff. It has the weakness of any setup governed by a committee instead of by an executive.

A committee is at best weak in execution. It has the advantage of bringing together the viewpoints of the group and its joint judgment is normally better than that of any individual in the group; but prompt, effective, and orderly execution depends upon the placing of authority and responsibility in the hands of one person and the faithful discharge by him of that responsibility,

including both the giving of the orders and the "follow-through" necessary to their proper execution. Therefore, the committee-type organization functions best when the chief executive himself is chairman and makes use of the committee to:

1. Strengthen his judgment.
2. Keep chosen staff members fully in touch and informed.
3. Promote the interest and coöperation of the committee members.

When made use of in this manner, the Type C organization merges into the Type A setup.

Failure to appreciate the limitations of the committee method is responsible for frequent examples of establishments having on paper excellent committee setups whose safety performance is disappointing. Too often the safety committee idea is borrowed from an establishment making successful use of it and is installed in a more or less perfunctory manner. The chief executive in such a case presumably views the method as a means of shouldering off most of the responsibility or agrees to the move upon the urging of an enthusiastic "safety salesman" (insurance or factory inspector, safety council member, or the like), who fails to make clear the fundamentals necessary to secure satisfactory results.

Safety committees in general

Although the advisable committee setup will depend chiefly on the size of the establishment, other factors have a bearing, such as the progress that has been made in safeguarding the plant when committee work is started, the size and relationship of the various departments or plant units, the type of business (manufacture, construction, transportation, public utilities, and the like). However, the following fundamentals at least should be met in forming the committee or committees decided upon:

1. Each committee should be so made up as to have standing appropriate to its field of work. For instance, a main or governing committee should include such key executives as master mechanic and production manager. A workers' committee should be made up of members well known to and having the respect of their fellow workmen.
2. The committee membership should encompass the maximum in knowledge of the methods, practices, and conditions in the plant, undertaking, or group represented.
3. The committee should be as small as is consistent with the above requirements. A committee of three functions more effec-

tively than does one of five. The larger the committee, the more the debate and the less the action.

When a committee is formed, certain matters of policy and procedure should be definitely set forth in writing. Written instructions should cover at least:

1. Scope of committee activity.
2. Extent of committee authority.
3. Procedure as to:
   a. Time and place of meetings.
   b. Frequency of meetings.
   c. Order of business.
   d. Records to be kept.
   e. Attendance requirements.

A committee will take its work seriously in proportion to management's attitude toward it. A management that sets up a committee to accomplish a specific purpose, makes it clear that it wants results, and gives effective executive supervision to its activities, will get satisfactory results. Effective committee conduct of safety work in the absence of executive leadership is possible only when committee members have unusual initiative and determination to advance the cause of safety. In such instances they often convert the nonsafety-minded management. Sometimes the "salesman" of safety, failing to arouse adequate management interest, can accomplish his purpose by getting a safety committee organized and aiding it to plan a program that will interest the top management, at the same time that he gets the job started.

While, as was pointed out, scope of activity, extent of authority, and the procedure to be followed should be put in writing and records of activities kept, this should not be carried too far. Too little system leads to confusion, waste motion, duplication of effort, and indirection. Too much system yields "red tape" and the needless expenditure of valuable time and effort. In other words, as is true of any other committee activity, safety committee work requires planning and orderly procedure under executive leadership.

In summation it can be said that the major advantages of committees are:

1. They bring together varying viewpoints and generally yield sounder decisions than does the individual viewpoint.

2. They widen interest by giving active participation to a number of persons in conducting the work.

Major weaknesses of committees are:

1. Group action requires deliberation and is, therefore, slow.
2. The meetings necessarily consume much time of many persons.

Commonly used types of safety committees are:

1. Main or governing committee.
2. Workmen's committee.
3. Technical committee.
4. Special-purpose committee.

A large plant may make use of all these types of committees; a small plant may use only one. The point is that once a definite decision is made as to the scope of the work to be handled by committee action, the type of committee needed and the number of committees required are readily determined.

The main or governing committee. The chief function of the main or governing committee is to determine the policy and set the standard or plane at which the safety work is to be conducted. The chief operating head of the plant or undertaking in question should be chairman. This makes it possible for the chair to issue definite orders to the various members as committee decisions are reached, and thus avoids both the delay and the possibility of overruling involved where committee decisions must be referred to a chief executive. It might appear that since the chief operating head can give orders at any time, the use of committees is of little value. If, however, he has an honest desire to strengthen his judgment from the opinions of the committee members and promote the interest of and full participation in the safety effort by every member of the committee, he will find the safety committee a very useful tool for the furtherance of safety.

Matters for determination by the main committee normally include:

1. Planning for the control of physical hazards concerning:
   a. Purchase of safe and properly guarded equipment, tools, supplies, etc.
   b. Relationships between various departments.
   c. Standards to be followed in guarding machinery, the design of equipment layout of process, etc.
2. Planning and arranging for the promotion of:
   a. Safe operating practices and procedures.
   b. Adequate inspection.
3. Planning and supervising programs of:
   a. Arousing and maintaining worker interest in safety.
   b. Safety training.
4. Disciplinary procedures.
5. Decision as to the disposal of specific problems.

6. Investigation of accidents.
7. Passing on specific recommendations.
8. Study of accidents and accident records.

It should be noted here that ordinarily the full committee will participate in the decision on policies and plans, but that action decided upon should be assigned to individuals or small sub-committees. Often such sub-committees consist of a member of the main committee as chairman with the other members not drawn from the main committee. This allows the use of technicians or other personnel as may be justified for specific purposes.

The workmen's committee. This type of committee, which is composed entirely of workmen or of workmen under the chairmanship of a foreman, can have great value, particularly in:

1. Bringing into the safety program the viewpoint and practical knowledge of the workmen.
2. Stimulating worker interest in safety.
3. Investigating accidents.

Fundamental to the effective functioning of a workmen's safety committee is the sincere desire of the management to enlist the help of the workers and obtain their faithful adherence to a course that will promote mutual confidence and respect. Workmen's committees should not be set up unless at least the following essentials have been provided for:

1. The work and place of the committee in the scheme of things is accepted as important.
2. All recommendations and suggestions made by the committee receive prompt consideration. If accepted, the action called for should be prompt. If rejected or modified by the chief executive or a higher committee, the reason for such rejection or modification should be clearly explained.
3. If a foreman or other supervisor is chairman, he should function as the chairman of a committee of equals, never as the "boss."

Firms using workmen's safety committees usually report their chief value to be that of promoting worker safety-mindedness. Until at least the more evident physical hazards are safeguarded, it is of little use to attempt to get worker coöperation to prevent accidents. Every workman knows that safeguards cost money, and efforts to get him to improve his work practices before obviously justified expenditures are made for safeguards will be taken as evidence of management's desire for safety "if it doesn't cost anything." All of which means that workmen's committees

should not be started until at least a reasonably good standard has been reached in the safeguarding of physical hazards.

Technical committees. As the name implies, technical committees are useful on specific problems or activities for which specialized knowledge is needed, as, for example, engineering revision, guard design, and special process problems. Some firms maintain standing technical committees under the chairmanship of the chief engineer, the safety engineer (if there is one), master mechanic, chief chemist, or other technician.

Special-purpose committees. Special committees may be set up for specific jobs; these are normally dismissed when their purpose is accomplished. Such jobs or purposes include contests, safety celebrations or award occasions, check-up accident investigations, rehabilitation or relief problems, special investigation of specific problems of worker behavior, off-the-job safety, and so on.

In some cases, particularly in small plants, it may be advisable to have a single committee including both supervisors and workmen. Such a committee to be effective must be conducted as a committee of equals. The workmen members of the committee may in fact be the most important part of it because in many situations their influence in promoting the safety-mindedness of their fellow workers may be greater than that of the supervisors.

Typical safety organization setups

Examples of safety organizations are shown on page 274.

It will be noted that as the organization grows in number the need for full-time specialists, who are trained to assist the supervisory personnel in the administration of their duties, is apparent. The following is the recommendation of a safety director responsible for the safety of a large manufacturing organization having many plants throughout the country—a man who has had an enviable safety record over the past few years.

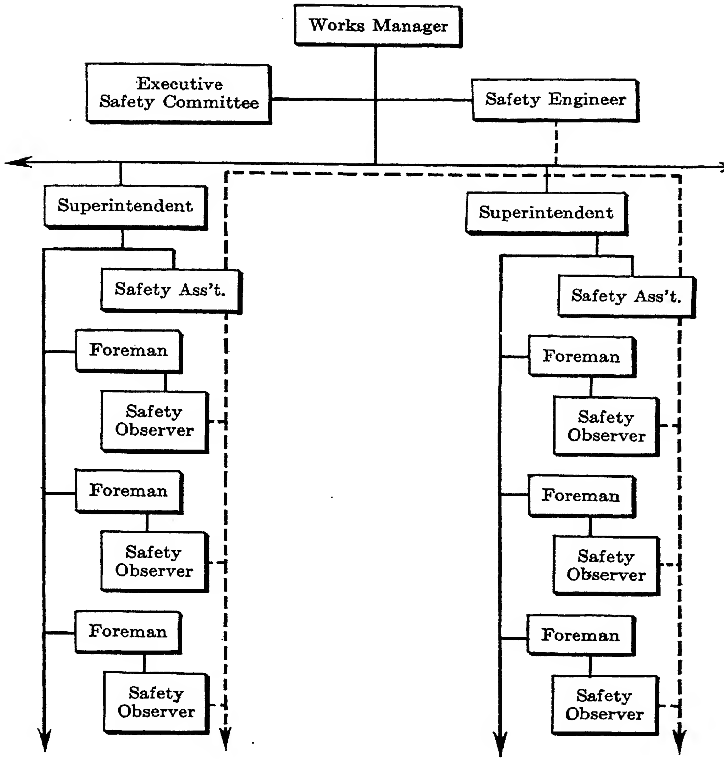
> The streamlined organization recommended holds the supervisory staff fully responsible for the elimination of plant accidents, yet relieves the supervisor of practically all the detail work. It provides for prompt action in the elimination of mechanical and personal hazards and does this with the minimum of persons involved.

This setup, shown on page 275, involves:

1. An executive committee reporting to the works manager on the matters of cost administration and projection of the overall plant accident-prevention activities.

2. A safety assistant reporting to each superintendent to specialize on the accident-prevention work within the division

Receives Advice and Council Through Following Agency	*Organization*	*How Policy is Carried Out*
Insurance Carriers Safety Inspector	**Plant No. 1** (0–1,000 Employees) Plant Manager Superintendent Foreman Foreman Workers	Superintendent carries out Safety Policy through Foreman's meetings, drives, etc.
Local Safety Council Safety Engineer, plus part-time man on the plant superintendent's staff.	**Plant No. 2** (0–2,000 Employees) Plant Manager Superintendent Foreman Foreman Workers	One man on Superintendent's staff devoting part time to safety training, statistics, inspection, etc.
Outside inspectors and speakers called in periodically.	**Plant No. 3** (Over 2,000) Plant Manager Safety Committee appointed by the Manager consisting of the Superintendent, Police Head, Works Engineer, Fire Chief, Personnel Manager, and Plant Physician, and one Foreman alternating each month. Foreman Foreman Foreman Workers	Regular meetings to discuss particular problems, review experience, and set plans.
Advisory Committee of Management Officials appointed by top Management, plus Union Representatives appointed by Union Officials.	**Plant No. 4** (Over 2,000 employees) Plant Manager Superintendents Foreman Foreman Foreman WORKERS	Personnel Director Chairman of Committee. Full time Safety Director coordinates Safety activities.



- Line Organization
- Advisory & Information

Number of Employees*	Safety Engineer	Full-time Safety Ass't.	Part-time Safety Ass't.	Safety Observers
0–1000			1	
1000–1999		1		One for each Dept. and one for each shift in Depts. working more than 1 shift
2000–2999	1			
3000–3999	1	1		
4000–5999	1	2		
6000–7999	1	3		
8000–9999	1	4		
Over 10,000	1 additional safety supervisor for each 2,000 employees			

* These figures are only approximate—the actual number required will vary with the type of work and the type of organization. Divisions made up of less than 1,000 employees may find it desirable to use only a part-time safety assistant.

much the same as the chief production clerk, chief inspector, and chief time-study man does in his specific line of work.

3. One or more safety observers selected by the foreman from volunteers within his department—men who will stimulate interest in safety and general employee welfare within the department.

The executive safety committee

The executive safety committee would be appointed by the works manager from members of his staff and would be required to set aside an hour or more each month to review the safety experience of the plant. This committee would discuss the progress made in such items as accident prevention, good housekeeping, fire prevention, and other activities involving the safety of the plant and its personnel. It would also help to project future plans for the further advancement of the accident-prevention program through the three basic elements of engineering, education, and enforcement. This committee may include four or more of the following:

- Manager of Manufacturing.
- Superintendent of Major Divisions.
- Police Chief.
- Fire Chief.
- Works Engineer.
- Supervisor of Time & Motion Study.
- Industrial Relations Supervisor.
- Safety Engineer.
- Plant Doctor.
- Works Accountant.
- Manager of Engineering.
- Union President and Chief Steward.

The safety supervisor

Each plant with 2,000 or more employees should appoint a full-time safety supervisor to coördinate the accident-prevention work within the plant. He would report to the Industrial Relations Department and would supply to the supervisory staff and safety organization the information necessary to provide safe working conditions for the employees.

Safety assistants

The superintendent or head of each major division within the plant should select from his organization an individual who can be assigned the responsibility for the safe working conditions within the division. This individual would report directly to the superintendent and would relieve the superintendent and his staff of much of the detail of accident-prevention work. This safety assistant may have the rating of an assistant foreman and should preferably be one who has a good knowledge of the work within the division and who could spend full time on this work, depending, of course, on the size of the division. A suggested basis would

be approximately one full-time safety assistant for each 2,000 employees. He would work in close coöperation with each of the foremen with respect to safeguarding equipment, eliminating unsafe conditions and practices, and the proper use and care of protective clothing. This safety assistant would also work in close coöperation with the safety engineer in the Industrial Relations Department and would control all of the workers' complaints pertaining to industrial and health hazards.

Employee participation

The value of active participation by employees in the plant accident-prevention program has long been recognized and should be retained. To accomplish this participation, the foreman of each department should appoint one or more employees as safety observers. These safety observers would work within their division in close coöperation with the safety assistant. Any suggestions or complaints pertaining to safe working conditions brought to them, or observed by them, would be taken up with the safety assistant. These observers should be selected from among those employees whose work permits them to "float" the department.

Union participation

The trend of the times would suggest that there be active union member participation in the accident-prevention program. Where relations with the union are amiable, this could be realized through the president of the union being made a member of the executive committee. In coöperation with the foreman of the department, he could recommend one of the safety observers within each department, possibly the union steward. In those plants where union representatives are members of the committee organization, these members have proved to be very effective in controlling the unsafe work habits of their fellow employees.

The appointment of these safety assistants and safety observers should not in any way relieve the supervisory staff of its responsibility for safe working conditions. It will, however, relieve the supervisors of a considerable amount of detail work and will expedite to a great extent the innumerable items that the supervisor has of necessity neglected because he did not have the time to follow them through.

REVIEW

1. What one thing is necessary to the effective functioning of any type of safety organization?

2. What are the three general types of safety organization?

3. What is the chief advantage of the Type A setup?

4. What type of organization is used by most large firms?

5. What are the major strengths of committees?

6. What are their major weaknesses?

7. What three fundamentals should be met in setting up a safety committee?

8. What are the chief values of committees of workmen?

9. What four types of safety committees are commonly used?

10. If the plant is organized, would you solicit union participation and coöperation on safety committees?

CHAPTER XXV

The New Employee

It is obviously important to train the new employee to work safely and efficiently in his new environment and at his new tasks. However, that a safe plant is of vital importance also is emphasized by the following summary of an analysis of one company's accident experience for the year 1942. Note that this company's plant would ordinarily be considered safe. The analysis showed that

MACHINERY	
was involved in	25% of all accidents. 66% of finger amputations.
HOISTING APPARATUS	
was involved in	10% of all accidents. 9 finger amputations. 5 fatalities.
VEHICLES	
were involved in	9% of all accidents. 3 amputations. 1 fatality.
BEING STRUCK BY:	
Falling, flying, rotating or moving objects caused	35% of all accidents.
BEING CAUGHT IN OR BETWEEN:	
Machines, machine parts or other objects caused	25% of all accidents.
STRIKING AGAINST:	
A stationary or moving object caused	13% of all accidents.
OVEREXERTION:	
on the part of the employee caused	11% of all accidents.
UNSAFE MECHANICAL CONDITIONS	
were present in	52% of all disabling accidents.

Of the total number of unsafe mechanical conditions, the three most important factors were (in their order of frequency):

1. Hazardous arrangement of materials, equipment, congested areas, and unsafe procedures.
2. Defective materials, parts, and equipment.
3. Improperly guarded equipment, machines, and areas.

These facts emphasize the importance of the work place, machinery, and equipment, and the need for regular and systematic inspection of all factors within the control of the departmental supervisor. Other chapters of this book deal with these factors specifically.

It is well, however, to point to the fact that we cannot expect to create among employees an enthusiasm with regard to their safety, if we do not present a work place in which people can be safe and machinery or equipment with which workers can work safely. No amount of regulation, instruction, publicity, or management insistence will bring about a decrease in accident frequency or severity if management is not willing to provide a work place, machinery, or equipment which exemplifies that safety of the worker is as important as production of the worker.

Another interesting phase of this same study, particularly relating to employee attitudes and practices, is presented to point to the need for proper instruction, training, and maintaining of safety interest and enthusiasm among workers at all times.

Unsafe Acts of the Injured or Other Persons
(The violation of a commonly accepted safe practice)

Unsafe Position or Posture	Use of Unsafe Equipment	Operating Equipment Without Authority
22%	14%	11%

Unsafe Personal Factors
(Such as mental or physical factors)

Improper Attitude on the Part of the Employee	Lack of Knowledge or Skill on the Part of the Employee
46%	25%

The three major factors of safety control so often expounded by the National Safety Council are:

ENGINEERING EDUCATION ENFORCEMENT

Engineering: as it relates to the proper safeguarding of machinery and equipment. Proper and safe department layouts, arrangement of materials, proper lighting, railings, guards, tools, and fixtures, paint hoods, exhausts and proper ventilation, goggles, leggings, etc., designed to safeguard the worker from accident and lost time.

Education: as it relates to the orientation of the new worker in the plant and the department; instructing him in the right way to perform his tasks; maintaining his interest and enthusiasm in maintaining the equipment, machinery, and the work place for his welfare on the job.

Enforcement: as it relates to the discipline of groups of people within an organization, working together, believing in the rules and regulations essential for safe operation for production.

Training the new employee

It has been said that job instruction rather than teaching workers to "pick up the job" means a reduction of accidents.

When we stop to think of our "first day at work," and realize how nervous and anxious we were to "get started" to earn some money, we can appreciate that the success of instruction may depend in great measure on the quality of the induction process.

A new or different place to work, whether for a new employee who has never had work experience or for one who has had experience, means an adjustment for the individual. It is also the first and real opportunity for a supervisor to establish a good relationship with the employee and to see that he gets accurate information about the job he is to perform, and the place where he is to work. For example, as one personnel director put it:

Recently I talked to George Seeman (age 50, previous experience, grocery store clerk) about his first week at work in an industrial plant. I quote his remarks:

"I was scared, I thought I wouldn't make it. The foreman showed me how to do the job. I guess I spoiled half of the pieces the first week. The foreman bawled me out every day. I was about ready to quit on Friday when I dropped a casting on my foot, and they sent me over to the hospital, and the foreman gave me a bad record for being careless."

No doubt this man was a problem to the foreman. On the other hand, I inquired as to why he was "scared," and why he hadn't made a better production record on a comparatively simple operation. Was it lack of proper instruction? Was it lack of understanding? Or was it fear of not making a good impression with his foreman? His remarks are interesting as they relate to the value of orientation of the worker to the work place and his surroundings.

"No, I guess he showed me how to do the job all right, but, I'd never worked in a shop before. I'd just lost my job that I had been on for fifteen years. I wanted to make good, but I was scared of the noise of the machine shop, I guess. I just couldn't get used to it. And there was a conveyor going over my head carrying some big castings which weighed about fifty pounds apiece. I guess they wouldn't have dropped on me, but I was always looking up at 'em. I guess that's what happened when I dropped the casting on my foot."

Very likely a little explanation concerning the equipment surrounding a new employee's work place, and a little encouragement at the start during the instruction period, would eliminate a great deal of nervousness on the part of the worker, and result in one less problem for the foreman, as well as more production and one less accident.

The process of making the employee "feel at home" is aptly brought out in the Training Within Industry's Bulletin No. 8 issued in February, 1942, under the title, *Introducing the New Employee to the Work Place.*[1]

Introducing the new employee to the job

C. R. Dooley, Training Within Industry Director, says:

It is easy for the new man (or woman) to jump to wrong conclusions. The supervisor has an excellent chance, during this impressionable period, to establish

[1] Training Within Industry, Bulletin No. 8, Feb., 1942. United States Office of Education, Washington, D. C.

a good relationship with the employee. He can get the new man off to the right start.

Some of the questions that arise in introducing employees are:

1. Can all employees be inducted alike?
2. What attention should be given to a transferred or rehired employee as compared with that given a new employee?
3. Is a systematized plan desirable?

In general, the information to be given employees should be the same, whether the employee is new or re-employed; the way in which it is given will depend on the individual employee and the organization.

It is probably enough to say that the supervisor's first approach to the employee will have considerable influence on the employee's future attitude toward the supervisor and the company and his attitude toward the work he is to perform.

The supervisor should draw on his experience in dealing with men and be careful to see that he does not make statements and perform actions that can be misinterpreted. It is an opportunity to establish a friendly attitude which will carry over into the job instruction process, for,

> *It is a principle of learning, that people learn faster and appreciate what they have learned when they want to learn and their minds are prepared for the learning process.*

The Training Within Industry program presents an interesting check list as a guide to supervisors, to remind them of the information to be given and to enable the supervisor to know what he has covered when it is necessary to contact the employee.

Most individuals who are new to an organization are concerned over how they will be accepted by their fellow workers. Getting off to the right start with fellow workers depends largely upon the employee himself, but the supervisor can see that the new worker is introduced in the vicinity of his work. In some instances, it may be desirable to tell the employee a few interesting things about his fellow workers.

One company requires all employees who have been hired within a week's period to assemble together in a hall where they are given an interesting series of lectures on various subjects pertaining to the company, its policies, rules and regulations; for example:

1. *Safety Rules and Practices*—by the Safety Engineer.
2. *Grievance Procedure*—by a Foreman.
3. *How You Get Paid*—by the Works Accountant.
4. *Promotion and Upgrading*—by the Personnel Department.

After the lectures, the employees are given an opportunity to ask questions pertaining to their work and work place, and each is given a questionnaire on which are questions pertaining to the lectures given. This is done to assure the lecturers that everyone has an understanding of the subjects presented.

INDUCTION GUIDE

For—(Employee's name).................... Employed........(Date)......................	Information given by	Date
1. Has he read the employees' handbook?		
2. Does he know safety rules, practices, and the reporting of accidents? Where to get first-aid treatment? Has he read the safety handbook?		
3. Have factory regulations—smoking, fire drills, absences, etc.—been explained?		
4. Does he know location of lockers and washrooms?		
5. Does he know location of cafeteria? Lunch and rest-period times?		
6. Was he informed about time-clock and clock-card rules?		
7. Does he know about passes—temporary, permanent, package, etc?		
8. Does he know organization of department, division, and shop? Names of supervisors?		
9. Does he know what the department manufactures?		
10. Has he been introduced to fellow workers, and told about company activities?		
11. Have company personnel policies been explained?		
12. Does he know how his pay is figured—piece-rate, incentives, learning period, overtime, payroll deductions, etc?		
13. Does he understand the benefit or insurance plan?		
14. Does he know where to get information? Help?		

Another company prepared a movie in an interesting and entertaining style, which brought out the various rules, regulations, policies, and other general information for new employees.

The Training Within Industry program presents a sample induction outline which might well be used wholly or in part, depending upon whether the organization is large or small. It suggests that the induction program cover a period of five days,

SAMPLE INDUCTION OUTLINE

When and where?	What and how?	By whom?
First Day 1. On arrival in plant	1. Introduction to working supervisor	1. By person who did hiring
2. On arrival in department—15 minutes	2. Information needed in daily routine: a. Any information he may need on getting to and from work, parking regulations, etc. b. Starting time, lunch period, quitting time, hours per week c. Review of compensation items (when he will be paid, where, how, how much) d. Opportunity for questions	2. By supervisor
3. Following preliminary interview—one-half hour	3. Meeting other workers, getting to know layout of building: a. Trip through department with general explanation of product b. Show him where he is to work and meet neighboring workers c. Show him his locker and location of wash rooms d. Show him the time clock, his card, and explain regulations. e. Tell him about any special rules on smoking, leaving department, etc.	3. By supervisor or group leader
4. Following (3)—till noon	4. Job instruction	4. By person who is to handle training
5. Noon	5. Show location of cafeteria and eat lunch with new man: a. Show him noon recreation facilities b. Introduce him to others	5. Neighboring worker
6. After lunch—till half hour before quitting time	6. Job instruction	6. Trainer
7. Half hour before closing	7. Give pass, explain use, and regulation in case of absence. Give booklet of rules, regulations, and policies to be read at home	7. Supervisor
Second Day 1. At a convenient time, one-half hour	1. Review booklet of rules and regulations, policies: a. to see that he understands subjects covered in booklet b. to give opportunity to ask questions	1. Supervisor
2. At a convenient time—15 minutes	2. Check through job with safety engineer and review policies and procedures on safety	2. Safety Engineer

SAMPLE INDUCTION OUTLINE—(Continued)

When and where?	What and how?	By whom?
Within First Week	1. Meet with other new men from other departments: a. Tour plant b. Have organization setup described c. Have mutual benefit and other organization plans described	1. Personnel Department
Fifth Day	1. Interview with supervisor—off job: a. Find out what he is thinking b. Clear up any misunderstanding c. Give opportunity for questions	1. Supervisor

basing its suggestion on the principle that "the mind can only absorb so much at one time, effectively."

Inducting the transferred or rehired employee

With increased production, the transferring and up-grading of employees, as well as the re-hiring of former employees—those on retired lists, married women, and so on—the proper induction of employees on new or different jobs, and the placement of former employees who have been "out of the habit" of continuous work are important factors in creating safe habits and even flow of production.

It is obvious that not as much information or attention will ordinarily have to be given to the rehired employee as to the new employee. But sometimes there is a failure to explain clearly to an employee the reasons for his transfer, an item of great concern to him. Although such an explanation may well be considered the responsibility of the former supervisor or the employment department, the new supervisor should, nevertheless, make sure that the transferred employee understands, and that any doubts he may have are expressed and talked over as early as possible.

However, it is well to appreciate that this employee will have to pass through an adjusting or orienting period similar to that of the new employee. Therefore, it is well not to take it for granted that such an employee is familiar with the company or the work; yet, to assume him totally ignorant may provoke his resentment. In addition to general information, he usually wants to know, and promptly, what grade of work he is to be assigned to, what his rate and probable earnings will be, what shift he will work on, and similar information that will let him know "where he stands."

Introducing an employee means that the supervisor obtains background information about the man as well as gives information

and assistance. The supervisor needs to know the man, and the man needs to know the supervisor, the department, and those with whom he is to work so that he will feel at home.

It is well to remember that the new or the transferred employee will get his information eventually, from one source or another—from other employees or perhaps through an experience the result of which will not necessarily make for harmonious work relationships. It is a supervisory responsibility to see to it that he gets the right information from the right source. Getting started right with the "boss" usually means staying right with him.

A few remarks that show the lack of understanding or information concerning work practices and policies that result from improper induction and instruction follow.

I didn't know it was to be done that way.
No one ever told me to see you about it.
I was told differently. That is why I did it this way.

The female employee

With the constantly increasing employment of women, induction and orientation to the shop becomes an essential to safe and continuous production.

It has been stated that labor turnover is greatest among female employees during the first two weeks of employment, and that the main causes are due to one of two or possibly both of the following:

1. Personalities surrounding them on the job. In other words, women are more likely to dislike their job because of a dislike of the supervisor than dislike of the job itself. This may be caused by impatience, lack of understanding, or criticism on the part of the supervisor.
2. Fear of some phase of the job or conditions around the work-place; discouragement, or fear that they cannot "make the grade."

Strangeness, inexperience, and discouragement are three important factors for supervisors to concern themselves with during the induction of female employees; and let us re-emphasize, with particular reference to female employees, that the success of the safety program will depend in great measure on the emphasis placed on safety in the induction process.

To meet the problems with which every supervisor must concern himself as women replace men, each plant must:

1. Establish a fair rate of pay for a woman doing a man's job.

2. Determine the types of work on which women can be employed, through a detailed study of jobs and giving consideration to all factors of the job to be performed by a woman, particularly those factors about the job which are hazardous.

3. Establish a satisfactory schedule of working hours. In most cases, hours are determined by state laws.

4. Set up good health and safety standards for women and sanitary restroom facilities. Safety regulations for women's clothing are essential and uniforms are recommended.

5. Develop simplified training programs for women. Women may not have mechanical *familiarity*, but they do have mechanical *ability*.

It is generally recognized that it is difficult to dictate the style of uniform that women shall wear. However, many companies employing large numbers of female workers have instituted effective programs to encourage women to wear uniforms at the work place.

From years of experience, men have discovered what clothes are most suitable for wear in factories; but women have always decided these things for themselves, individually. However, now that they are being mobilized into factories to do many jobs formerly done only by men, women must be educated in this respect.

First, the clothing a woman wears on the production line must be functional. She is there to do a man's job, and she must not be hindered by impractical clothing. Style must not be forgotten, however. Unattractive costumes dictated by regulations affect women's morale, while attractive clothing made with consideration for style helps to "keep up morale" and aids in bringing about a wider acceptance of safe clothing by women workers.

A few basic requisites of work clothing for women are practical necessities. The fabric should be sturdy enough to withstand heavy strain, and still light and soft enough for comfort: whipcord, men's-wear cottons, cotton sheetings, unbleached muslins that can be dyed, and even men's-wear spun rayon suitings. The preference generally seems to be for cotton fabrics. "We may have to wash these outfits ourselves on occasion, and we may be in a hurry," the employees say. For women employed on heavy work, asbestos aprons, or clothing impregnated with water-repellent or non-inflammable compounds are best.

For light factory work, culotte dresses, smocks, Hooverettes, aprons, and wash dresses are favorite types of apparel. The usual leaning is toward bright, gay prints and floral patterns.

Necessary fullness and other constructional details to allow freedom of action in reaching, bending, sitting, and kneeling are important.

A few companies employing women workers furnish standard uniforms for all, but the majority allow the women to pick their own working costumes. The following are a few "musts" for consideration in feminine work clothes:[2]

1. A color and style becoming to the wearer.
2. Sturdy, strong, preshrunk material.
3. A simple design with nothing to catch in machines.
4. Design and material that is easily laundered.
5. Necessary fullness to allow for all movements.
6. An outfit that is easy to put on and take off.

The safety factor must always be remembered when work clothing for women is considered.

There should be nothing about such clothing to catch in machines or to cause accidents. For efficiency's sake, the costumes must be easy to put on and take off.

Another safety recommendation is trousers. Although they are not always required, in general they are deemed better where women do standing-up jobs near moving machinery or where they have to move about a good deal.

An important safety factor is the arrangement of the hair. The long "glamor bob," though it may be very becoming to its wearer, is dangerous unless it is covered with a hat, snood, net, or kerchief. The chief danger is that a few hairs may get caught in the machinery and pull in the whole head.

Types of shoes are usually determined by the kind of work performed. Shoes with closed toes, box toes, or reinforced toes are recommended for factories where metal filings collect on floors or where heavy parts are handled. Protection against hot materials, acids, or excessive moisture requires a particularly heavy shoe.

Additional personal safety equipment such as goggles, gloves, welders' helmets, sleeves, and respirators, further protect female employees from the hazards of the specific job. Women have demonstrated that they are not afraid to soil their hands; however, strong, heavy gloves afford protection to feminine fingers.

The following is interesting as it relates to the subject of women workers and feminine accident hazards as revealed by a safety pledge taken by women workers of the Todd Shipyards:

[2] National Association of Manufacturers, September, 1942. (Service for Plant Publications.)

I Promise:

To have no loose ends on my clothing.
To leave all jewelry at home or in my locker.
To keep my pockets buttoned.
To keep my ankle and wrist cuffs securely closed.
To keep my hair completely covered and my fingernails short.[3]

Aids to making women safe-clothes-conscious[4]

The house magazine may be used effectively to promote the adoption of safe, practical working clothes by the women in a plant. For example, its pages may be used to introduce and conduct any one of several types of contests to create interest in the problem among the women.

A typical contest might offer to the working women an opportunity to design the type of work clothes they would like to wear. Designs are to be judged on such bases as safety, style, freedom of movement, freedom from unnecessary frills, and adaptation to type of work performed.

Judging could be handled by a specially chosen committee, an outside stylist, or by vote of all the women workers. Naturally the variations in artistic talent among the women pose a problem in the presentation of their ideas. This difficulty could be overcome by making an artist available for sketching from written suggestions made by the women—or, by basing the entire contest on written suggestions.

Another type of contest practicable for presentation in the house magazine could consist of the use of its pages to present styles of work clothes already being manufactured. The women would be urged to write letters voting for the styles that appeal to them the most, the letters being used as a basis for awards and possibly for the adoption of a standard garment.

Such contests presuppose that the company has not already adopted some standard form of dress for women employees. However, some manufacturers have discovered that prescribed garments have not met with enthusiastic reception from the standpoint of either style or utility. Where such is the case, the contests may still be used. The purpose would be changed, of course, to paving the way for modifications or complete restyling of the present uniforms as wear necessitates replacement.

Make the women work-clothes conscious, give them a say in the choice of garments, and the problem is well on its way toward solution.

[3] *Modern Industry*, December 5, 1942.
[4] National Association of Manufacturers, September, 1943. (Service For Plant Publications.)

Following is an example of union-management collaboration giving consideration to safety and setting up regulations for women in industry:

The question of Safety Provisions for Women on War Emergency Jobs has been a subject of collective bargaining between the Negotiating Committee of Local 601 U.E.R.M.W.A. and Management.

The following covers the Safety Provisions for Women on War Emergency Jobs:

One of the most important factors in the successful utilization of women for war jobs will be the consideration given to safety. The full coöperation of every employee accepted for this work is necessary for her proper protection from accidents.

The following minimum requirements are established.

1. Employees shall report for work attired in slacks and neat-fitting blouses or shirtwaists with short sleeves. Arm shields shall be provided where these are necessary because of flying chips.
2. Rings or jewelry of any type shall not be worn while at work.
3. Hair nets or other head covering in accordance with standard safety specifications shall be worn by all operators.
4. Neckties, bandanas, or handkerchiefs worn in such a way that they may become entangled in moving objects create a hazard and shall not be worn.
5. Safety shoes are strongly recommended and each woman is encouraged to wear them. They are on sale at the Safety Department (SS Bldg.) where they may be purchased at cost and by payroll deduction. Low heels are preferable; cuban heels are the highest that may be worn.
6. While gloves protect the hands in handling materials, they shall not be permitted on machine operations.
7. Goggles of the lightest weight sufficient to meet the requirements of the job shall be provided and must be worn at all times.
8. Approved aprons, overalls or coveralls, may be worn over other wearing apparel to protect employee's clothing.

Instruction on the Job[5]

You are about to instruct an employee in the performance of his job. This is very important to him, to you, and to national war production.

Perhaps the employee has been with you for years. Perhaps he has been transferred to you. Maybe he is green—starting his first job. Or perhaps he has had long experience in a nondefense industry and is starting his new work on war production.

Here are some ideas presented by the War Manpower Commission's Training Within Industry Committee:

[5] *Training Within Industry Bulletin*, May, 1942.

What You Want to Do:

Go back in your own memory. Remember how you felt the first day on a new job?—the time you were "stumped" by a new "wrinkle" on the job?—the time when you caused some scrap or re-work?—the time you got hurt?—the times when the boss corrected you and your work? Perhaps you liked the way he did it—or perhaps—you didn't?

Any worker assigned to you feels the same way. He wants to make a good showing. You realize this. You are interested in four things:

1. Having the new worker come up to the quality and quantity requirements of production as quickly as possible.
2. *Avoiding accidents which will injure the worker.*
3. Avoiding damage to machines or equipment.
4. Spoiling as little work as possible.

How You Can Do It:

Most of us just "jump right in" and start instructing or correcting a workman without much thought or planning. Perhaps you do the same.

—You know the job so well that you've forgotten the things that "stump" the learner.
—You know it so well that you don't *plan* how to "put it over."
—You know it so well that you don't pick out the "key points"—the "knacks" —the things that make or break the operation.

To instruct a man *rightly* takes just a little extra time at the moment, but it saves hours and days of time later on and prevents a large part of the scrap, spoiled work, and accidents. The following plan is simple and easy to follow. Furthermore, it works.

—*Before* instructing, there are four GET READY points for you to watch. You can do them in a few minutes.
—*When* instructing there are FOUR BASIC STEPS to follow. They really are no different than what you may now be doing. But they help you do it *well* and *thoroughly*. At least they have helped thousands of others.

How to GET READY to Instruct:

Here are the four GET READY points you should take care of before instructing:

1. *Have a time table:*

   —How much skill do you want the man to have?
   —How soon?

   When faced with a "breaking in" problem, don't say what all too many of us say—"IT TAKES TIME . . . ," or "HE JUST HAS TO LEARN." Say to yourself instead: "HOW *MUCH* TIME ——?"

   Here is an easy way to do it. Answer to yourself this statement: "___(employee)___ should be able to ___(do what job)___ and do it ___(how well)___ by ___(what date)___."

   Better yet, put down the names of your men on a piece of paper. Set yourself some dates when you are going to try to have them able to do the

jobs they need to know. *Time is short.* Have a time table for yourself and your men.

2. *Break down the job:*

   You know that there is *one right way* to do every job. You know too that there are a few "*key points*" in every operation that make or break it. If these key things are done rightly, the whole operation is right. *If any* one of them is missed, the operation is wrong.

   —If you put the job over to the worker with these key points made clear, he will really "get it."

   —He will do the operation right the *first time.*

   —He won't be "fighting" the work—making mistakes—*getting hurt.*

   There is an easy, quick way to get the job clearly outlined in your mind. Fill out a "Breakdown sheet" (sample enclosed) for each of your operations. It only takes three to five minutes. This is for your own use. It is not to be given to the worker.

3. *Have everything ready:*

   —The right tools, equipment and materials.

   When you so much as "touch" a job in front of a worker, set the *correct* example. Don't use the wrong tool: Don't fumble. Don't excuse. Don't miss a trick. When *you* have everything right, *he* is more likely to do the same.

4. *Have the work place properly arranged:*

   —Just as the worker is expected to keep it.

   The same thing applies here as above. You must set the correct example. Put his bench, desk, stock pile or wherever he is to work, *in proper order,* before you start to put over the job to him. *He* won't do it if *you* don't do it.

How to INSTRUCT:

Here is what you should do every time you instruct a man or correct his work:

STEP I. *Prepare the worker to receive the instruction:*

—Put him at ease. Remember he can't think straight if you make him embarrassed or scared.

—Find out what he already knows about this job. Don't tell him things he already knows. Start in where his knowledge ends.

—Get him interested. Relate his job or operation to the final product, so he knows his work is important.

—Put him in the right position. Don't have him see the job backwards or from any other angle than that from which he will work.

STEP II. *Present the operation:*

—Tell him, show him, illustrate, ask.

—"Put it over" in small "doses." He (the same as all of us) can't catch but six or eight new ideas at one time and *really understand* them.

—Make the "key points" clear. These will make or break the operation—maybe make or break *him.*

—Be patient—and go *slowly.* Get accuracy now—speed later.

—Repeat the job and the explanation if necessary.

STEP III. *Try out his performance:*

—Have him do the job, but watch him.
—Then have him do it again, but have him EXPLAIN to YOU what he is doing and why. All of us find it easy to observe motions and not really understand what we are doing. YOU want him to UNDERSTAND.
—Have him explain the key points.
—Correct his errors, but don't bawl him out or indicate that he is "thick" or "dumb."
—Continue doing all this until YOU know HE knows. He may have to do the job half a dozen times.

STEP IV. *Follow-up:*

—Put him on his own. He has to "get the feel" of the job by doing it himself.
—Tell him whom he should go to if he needs help. Make this definite—yourself or someone *you* designate. The wrong person might give him a "bum steer."
—Check him frequently—perhaps every few minutes at the start to every few hours or few days later on. Be on the lookout for any incorrect or unnecessary moves. Be careful about *your* taking over the job too soon, or too often. Don't take it over *at all* if you can point out the helps he needs.
—Get him to look for key points as he progresses.
—Taper off this extra coaching until he is able to work under normal supervision.

Use this plan. You will find it amazing that such greatly improved results can come from such a simple plan.

Remember, accidents have been the results of—

Incomplete Training.
Lack of Specific Information.
Conflicting Instructions.
and General Ignorance.

IF THE WORKER HASN'T LEARNED, THE INSTRUCTOR HASN'T TAUGHT!
"THE RIGHT WAY IS THE SAFE WAY"

The Job Breakdown Sheet on page 294 may be used for:

1. Analyzing a work situation.
2. Discovering the sequence of operations to be taught, the key points to be emphasized, and the hazards to be guarded against.

The following accident is typical:

Shaft flew out of the chuck, striking an operator who was working at another machine. The man was taken to the hospital.

Further investigation indicated that when the cutting tool was brought up to the work for a heavy cut of the metal, the piece flew out of the chuck, resulting (in this particular instance) in an

BREAKDOWN SHEET FOR TRAINING MAN ON NEW JOB

Part Shaft ______ Operation Turning diameter to size in 3-jaw universal chuck.

IMPORTANT STEPS IN THE OPERATION Step: A logical segment of the operation when something happens to ADVANCE the work	MENTAL ACTION How? Why? When? Where?	KEY POINTS Key point: Anything in a step that might Make or break the job Injure the worker Make the work easier to do, i.e., "knack," "trick," special timing, bit of special information
Pick up piece and place in chuck jaws	Right hand	
Pick up chuck wrench and place in chuck	In square hole	
Tighten chuck	Both hands	Tighten as tight as possible with both hands on wrench to prevent piece from flying out and striking operator
		Remove chuck wrench from chuck before starting machine to prevent injury and damage
Start lathe	Press black button	
Bring tool in position	Turn hand wheel on carriage	

accident causing loss of time, loss of material, and broken tools. The worker himself lost confidence and was afraid to continue the work.

The breakdown sheet on page 294 indicates what steps should have been taken if accidents on this particular job were to be avoided.

Note the key points which were discovered when the job was analyzed with the aid of the breakdown sheet.

1. Tighten as tight as possible with both hands on wrench to prevent the piece from flying out and striking the operators or hurting someone.
2. Remove the chuck wrench from the chuck before starting the machine to prevent injury and damage to the equipment.

In other words, the analysis brought out two key factors to consider and to stress when training the worker to do the job.

1. Getting the piece *secure* in the chuck when the tool is brought up to the work when making a heavy cut.
2. Taking the chuck wrench out of the machine *before* starting the machine.

With this background of information and the teaching steps known, we are ready to instruct the worker in the proper performance of the task to be performed as well as the safe practices of doing the work.

We know *what* to instruct; our next step is to consider *how*. In other words, we should consider the best way to transfer these ideas to the mind of the listener so that he will have learned what we have taught him and will remember it when occasion arises.

Dr. Harold S. Hulbert says, "If we are to deal with other persons, it is quite important that we think clearly and speak understandably. The inability of people to speak understandably is the greatest handicap of people. We are not able to communicate our ideas one to another fully or exactly. How then can you get your ideas across to the other person?" He recommends first, "that you be very explicit, that when you are talking to a person you do not talk in an involved way. When you talk to other persons, make it easy for them to think, to agree, to follow. Do not express yourself in such a way that they have to rearrange your ideas before they understand them or use them."

He illustrates his point with the following story:

A foreman was showing a new workman through his department in a large paint factory, and he explained to the man in passing: "In case of fire, *do not* leave that door open."

There was a fire later. The inquest brought out the fact that the workman remembered that the foreman had said "something about that door being open in case of fire." (Remember, the foreman had said, "In case of fire, *do not* leave

that door open.") So, the workman opened the door. The foreman should have said, "In case of fire, shut that door."

Then the man could have received that idea and kept it in the storehouse of his memory. He would have been able to bring it out when needed and could have put it into action without having to rearrange the thought.

Dr. Hulbert urges positive talk when issuing instruction for safe practices.

The following plan called "A Talk Plan" is invaluable in putting one's mind in order for positive talking. It was developed by the Sales Analysis Institute of New York in the interest of more effective instruction. The accident illustrated above is used in this talk plan.

The Good That Comes from	The Right Action	vs	The Wrong Action	The Harm That Results
Save Yourself Injury Time The Company Tools Machinery	Take the wrench out before starting the machine Make the piece secure and tight when feeding the cutting tool into heavy cuts		Leaving the wrench in will cause Leaving the pieces loose will cause	Injury Lost time Money loss Spoiled work Broken tools

The "talk plan" in action would sound something like this: "You will save yourself a lot of time, conserve the tools and your machine, Joe, by *taking the chuck wrench out* (like this), before starting the machine. *Make the piece secure with both hands,* Joe (like this), when you have heavy cuts to make."

Confusion and possibly fear is likely to be created in the learner by using this manner: "*Leaving the wrench in the machine* will *injure somebody,* Joe. *You will spoil the work and break the machine.*"

An important principle about TRAINING and its relation to LEADERSHIP was expressed by Dr. Harold S. Hulbert at the Twenty-ninth National Safety Congress, Chicago, Illinois, October 7–11, 1940.

Before a workman or anyone else can accept *you* as a *leader,* he has to sense that in *you* is an approval of *him* from *you* if he measures up and grows the way *you* want *him* to. *He will not accept you as a leader until then.*

REVIEW

1. Why is the first day on the job so important?
2. When should safety instruction begin?

3. What do people learn fastest?

4. Why should as much information as practicable be secured about a new employee before he is put to work?

5. What five specific things should each plant do for its women employees?

6. Why is even more attention to guarding machinery necessary for women than for men?

7. What are the four "get-ready" points in job instruction?

8. What are the four steps in job instruction?

9. What is meant by "key points"?

10. Why should instruction generally be positive rather than negative?

CHAPTER XXVI

Safety and Health Standards and Rules

Standards are essential to an industrial civilization. Each branch of science, each field of industrial activity must as it grows develop standards on which to base, measure, and compare its achievements and performance.

Standards may be said to develop by a process of crystallization from industrial progress. A new method or process is found; when proved and sufficiently applied, it yields certain standards which, properly used and observed, can be depended on to bring dependable results.

Industrial safety is a new and rapidly developing field. It has developed many standards, but many more are needed. Also many of the existing standards need further refinement. Safety standards may be classified in two groups, namely:

1. *Voluntary, self-applied standards.* The various interests, groups, and individuals engaged in the work of accident prevention have developed standards representative of good practice. Since the purpose is to prevent accidents, the standards amount to a crystallization of experience and are accepted and observed only by virtue of their practical value as aids to prevention.
2. *Regulatory standards.* Laws or rules, having the force and effect of law, have been adopted by governments for the purpose of securing the correction of specific hazardous conditions and of setting forth certain requirements deemed necessary to safety.

The development of voluntary, self-applied standards

The development of formal industrial standards for both voluntary adoption by industry and regulatory adoption by states was given great impetus by the production necessities of the first world war. The multiplicity of standards used by competing manufacturers was a serious barrier to the needed volume production of essential goods. Under governmental sponsorship, the American Engineering Standards Committee was formed for the purpose of developing standards that would receive national acceptance and displace the conflicting and unnecessary ones. In 1919 the scope of the Committee's activities was broadened to

include the drafting of safety standards. With the broadened scope, and widened membership, the organization became American Standards Association. By 1939 ASA was composed of 71 national organizations as member-bodies and associate members, and some 2,000 company members. The production requirements of the second world war have given an emergency status to the ASA work requiring an intensification of its activities in certain directions and abridgement in others; but, on the whole, involving a notable expansion of its usefulness and greater use and acceptance of "American Standards." The Federal Government through various of its agencies is coöperating in the drafting of "American Standards," and in addition certain agencies, notably the National Bureau of Standards, the United States Bureau of Mines, the United States Public Health Service, and the United States Department of Labor, develop informational material that is, or approaches, the status of standards.

American Standards Association

Briefly, the make-up and functions of the ASA are as follows:

A. Board of Directors. The executive, financial, and general administrative functions of the Association are in the hands of a Board of Directors.

B. Standards Council. The Standards Council has general supervision over the development of standards. It is composed of representatives of all of the member-bodies of the Association. It approves the initiation of projects, the scope of the undertakings, the personnel of committees, and finally it sets the approval of the Association on the resulting document as an American Standard or as an American Recommended Practice. Approval of a standard is based on:

1. Regularity of procedure in the development of the standard.
2. Adequacy of representation of the committee responsible for the development of the standard.
3. The degree of unanimity reached in the committee.
4. The status of the proposed standard.

C. Correlating committees. Where standardization activities in a major industrial field are sufficiently extensive to warrant it, correlating committees aid the Standards Council. They coördinate ASA work in their respective fields, and through them standards are passed on to the Standards Council for final approval. Such industry or correlating committees have been set up in the building, consumer goods, electrical, highway traffic, mechanical, mining, and safety fields.

D. Library and standards information. The Association provides a general information service for the use of its members and committees. This service includes a library of approximately 20,000 American and foreign standards and related material.

E. ASA headquarters. The routine work of the ASA is carried on by a technical staff, who follow the various standardization projects and assist in their orderly development. The headquarters of the Association are located in the Engineering Societies' Building, 29 West 39th Street, New York, New York.

The work on safety codes is under the advisory direction of the Safety Code Correlating Committee. Its functions include:

1. Investigating the need for particular standards.
2. Defining and limiting the scope of standards.
3. Considering the interrelation of standards.
4. Passing upon the personnel of technical committees.
5. Following up the work on standards.
6. Acting as a general clearing house on safety standards.

It is just as necessary if a standard is to become of real practical value that its provisions represent a consensus of those interested as well as the need for it to be generally appreciated. A sectional committee for a safety standard, therefore, is approved by the American Standards Association on recommendation of the Safety Code Correlating Committee only when it includes a balanced representation of those concerned. This representation covers manufacturers, employers, employees, governmental bodies, qualified specialists, and insurance representatives.

When a code has been formulated, it is recommended by the sponsor for approval by the ASA. In order to secure adequate advice, the question of approval is referred to the Safety Code Correlating Committee for recommendation on whether the procedure has been followed and whether the vote of the technical committee shows a sufficient consensus. Upon favorable report, the code is then approved by the ASA and, as an American Standard, it is brought to the attention of government officials, insurance companies, and industries concerned. The technical committee is continued to provide for revisions and to interpret the provisions.

Current lists of American Standards may be had from ASA headquarters upon request. By 1943 this list included over 80 standards in the field of safety and health alone.

Some of the standards approved by ASA have been developed by other groups and then submitted for ASA consideration and approval as American Standard. Notable among these standards

is the Building Exits Code, developed under the leadership of National Fire Protection Association. In similar fashion, the Associated General Contractors of America prepared a volume on safety practice in construction under the title *Manual of Accident Prevention in Construction.* It was approved as "American Recommended Practice." Meanwhile, the development of a Construction Safety Code is being carried on by a sectional committee.

The ASA procedure has won a remarkable degree of acceptance and coöperation from the various technical groups and organizations. However, some standards antedate ASA and some well-established standards have not been submitted to it for approval. Outstanding among these are the Power Boiler Code and the Unfired Pressure Vessel Code developed by the American Society of Mechanical Engineers. These codes are fruits of a vast amount of experience and constitute the standards for judging the safety of the types of pressure vessels covered.

Various other technical or industrial groups have developed safety (or health, or both) standards. Such groups include the Portland Cement Association, the American Petroleum Institute, the Manufacturing Chemists Association, the American Society of Heating and Ventilating Engineers, and the Illuminating Engineers Society—to name only a few. Any person wishing to obtain information as to such standards and standardized safety procedures in a particular industry or profession should inquire of the organization representing the group in question.

Regulatory standards

The effort to eliminate hazardous working conditions by legislative enactments has, through a long process of trial and error, finally developed a method that properly applied combines quite effectively the force of law with the educative and stimulative methods through which National Safety Council and allied agencies have made great gains in reducing accidents.

The first legislative attack on accidents was simply one of the prohibition of specific hazards. This method necessitates detailed legislation which involves the following difficulties:

1. Legislative enactments are difficult to modify and thus their detail cannot be kept in accord with the changing needs of our developing industry.
2. Occupational hazards are so numerous and varied that detailed legislation cannot cover them even reasonably well without becoming impossibly complex.

3. Such detailed legislation cannot be enforced without causing hardship in so many instances that it will largely defeat its purpose.
4. Securing reasonable uniformity in such detailed enactments by the legislatures of the various states and the Federal Congress is a practical impossibility.

These difficulties are being increasingly met by the enactment of legislation which in simple direct language:

1. Requires employers to provide safe work places and safe conditions of work for their employees and do everything reasonably necessary to prevent their injury while at work.
2. Delegates to a specific agency the duty of drafting rules (and standards) necessary to carry out the intent of the law and of revising and modifying these as conditions require.
3. Describes the procedure required to avoid abridgement of constitutional rights and liberties. Such legislation has been so sufficiently reviewed by the courts that the proper procedure is clear. Its advantages have been so definitely proved that the states are increasingly turning to it. By 1943, some 18 states had adopted legislation of this nature and several other legislatures had it under consideration. Several states have built up extensive systems of safety codes under such laws. Chief among these are California, Massachusetts, New York, Pennsylvania, Ohio, and Wisconsin.

The procedure in drafting these codes should be substantially as follows:

1. All groups having a legitimate interest in the standard to be drafted are invited to take part in its drafting.
2. The inspection service agency having the duty of administering the standards usually prepares tentative drafts and submits identical copies to a committee representing all interested groups.
3. These tentative standards with changes or additions as approved by this committee then go to the approval authority for its consideration and action as required under the law.

The process of working out safety standards by this method involves the interchange of ideas among individuals and groups who may not and often do not have any other opportunity for such exchanges. This results almost invariably in fostering coöperative effort in the interest of safety. Furthermore, those who aid in the development of such standards almost invariably become advocates of their use and thus their acceptance grows.

Safety standards to be worth the effort that is required to develop them must not only be practical, but they must secure a good degree of acceptance. If they are developed through the combined efforts of all interested parties, they will be practical; but they must be known about and talked about, that is, advertised, if they are to secure acceptance. Safety men everywhere should take an active interest in developing and promoting the use of suitable safety standards. So should manufacturers, technicians, and organized labor. The safety man is in a favorable position to promote the interest of all these groups in safety standards.

In drafting state safety requirements, it is very advantageous to adopt directly or at least to follow closely the provisions of applicable "American Standards" for the following reasons:

1. The method of their development insures that they represent good practice.
2. The method of their development and the degree of voluntary acceptance they thereby receive gives practical assurance that their provisions are in fact sound and reasonably necessary for safety and that the courts will usually so hold.
3. This course will prevent conflicts among the requirements of the various states.

The aim of every state should be to construct by means of mandatory requirements a floor for safety and health at a level representing the minimum conditions that may be permitted in work places.

Performance above this level (incidentally most of the job of accident elimination must be done above this floor of minimum acceptable performance) should be encouraged by advisory rules or recommendations.

States vary in their methods of presenting rules and recommendations. The usual method is to present the legal requirements and advisory material in separate documents. However, several states have recently experimented with a single booklet in which preventive methods are discussed subject by subject and, at the end of each such subject, the pertinent mandatory rules are set forth in bold type. The "Basic Safety Manual," published by the Department of Industrial Relations of Alabama, is an excellent example. A similar method has been used in the ASA Safety Code on Power Presses and Foot and Hand Presses, which presents information on safe operation in a column parallel to one presenting the rules.

When drafting standards dealing with machinery, such as elevators, for which the expense of safeguarding existing installations in accordance with the applicable ASA code would be unduly heavy, some states adopt the ASA code for installations to be made after a specified date and relax its requirements reasonably for existing installations.

Since a large proportion of injuries come from equipment or machinery common to practically all industries, most states find it advantageous to deal with these hazards through standards covering the equipment rather than the industry. Standards on transmission-machinery guarding, portable ladders, stairways, or powered hand tools fall in this class. In addition to standards of this nature, hazards peculiar to a given industry, such as foundries, dry cleaning, or quarrying, require special standards. But a foundry, for instance, would be aided by standards on ladders, stairs, transmission-machinery guarding, powered hand tools, and so on, as well as one dealing with hazards ordinarily found only in foundries. (The ASA applies this principle in developing its standards.)

It is important to avoid conflicts with the codes and standards of other states. The effective way to avoid such conflicts is to conform as closely with the ASA safety standards as local conditions will permit, for there are practically no other safety standards of national acceptance. The seriousness of conflicts lies in the following situations:

1. Where conflicts exist among state requirements for guarding machinery, manufacturers of the machines involved cannot design and guard their products for maximum safety. Guarding in such cases must be by or on order of the purchaser—in other words, "afterthought" guarding, which is rarely as effective as designed-in and built-in safeguarding. An outstanding instance of this fact is the ordinary circular table saw, undoubtedly the greatest producer of human injury among industrial machines. Since there are no clear and definite requirements on the guarding of such saws, and since state requirements vary widely, none of them are fully guarded by their manufacturers. No fully satisfactory guard has been developed for application to standard models of table saws, but all models could be adequately guarded if the guarding were included in the design.

2. Many firms operate plants in several states. They suffer hardship in meeting different sets of requirements.

3. Workers meeting with different degrees of protection through safety standards in different states become resentful or

suspicious and tend to withhold the whole-hearted coöperation so needed in preventive work.

A few states furnish material supplementary to such formally drafted safety standards in the form of a handbook for the guidance of the state safety inspectors. The handbook covers procedure for inspection service, together with information helpful to the safety inspector in his daily work. Such a handbook is exceedingly important. Without carefully worked-out and well-maintained means of training and instructing its safety inspectors, no state can hope to render a safety service that will reasonably measure up to the need or opportunity. If a force of safety inspectors is to pass on performance under even the most complete and well-ordered structure of safety standards, there must be a good degree of uniformity in the information each gives and the advice each tenders to meet similar hazards.

Plant standards and rules

As already pointed out, each plant must have certain production standards, even though in small, loosely managed and relatively unorganized establishments these may exist mostly in the "know how" of the supervisors and their experienced workmen. At the other extreme is the modern highly developed plant devoted to the quantity production of a complicated machine which requires not only a great number of drawings, but also performance standards in almost endless detail. For instance, the weight of drawings required to put the four-motored bomber into mass production are said to exceed greatly the maximum load capacity of one of these air giants.

Safety benefits from all this exactitude of detail; for exactitude spells control, and adequate control of any activity yields safety. But as already pointed out in the discussion of job analysis, the planning and control necessary for mass production is rarely extended to activities not in direct production unless done in the interest of safety. But it is increasingly being so extended that, in establishments representative of top safety performance, we find a very considerable mass of safety standards developed to cover specific activities and conditions within the establishment not adequately dealt with by production standards. In addition to job safety standards, these include standards for safeguarding and safety equipment, inspection standards, safe practices, and safety rules.

This is a very important field, justifying much further development in the great majority of industrial establishments. Also the

technique of its development particularly as regards safe practice standards and safety rules should be given much more attention. Making a physical plant safe and keeping it so is a relatively simple matter. Nor is it difficult to work out safe procedures or to arrive at the wording of rules that are expressive of such procedure. But to get all of the working force to follow safe practices faithfully and consistently is much more difficult. Success in doing so will be determined almost wholly by the extent to which the workmen come to believe in the value of following such rules of safe practice. This means, then, that in developing such rules it is essential that:

1. Every rule be practical from the viewpoint of those to whom it applies.
2. Each hazard or condition dealt with by a rule be definitely demonstrable as unsafe.
3. Rules be limited to safety matters. Extraneous matters, regardless of their importance, should not be dealt with in safety rules.
4. The workmen affected must have a full part in developing the rules.

The last item is the most important of all; so important, in fact, that it is probably true that really satisfactory observance of safety rules is not obtainable otherwise. If a plant is organized, the union can contribute importantly to the safety of its members by taking a position of leadership in working out rules of safe practice and in promoting their acceptance.

Many establishments have developed safety rule books containing rules of general applicability. It is quite common practice to issue a copy to each employee (particularly each new one) and require from him in due course a signed statement that he has read, understands, and will observe the rules therein. This course is of little practical value unless the rules and the justification for each rule are really understood by the employee. A rule that a workman had a part in developing will be understood by him. If he knows that his fellows developed the rules, he will be strongly inclined to believe in them. He will accept them gladly from a foreman he likes and respects. In all cases, whatever instruction and explanation is required to enable him to realize the value of the rule and the reasons why he should observe it is necessary if a good degree of observance is to be had.

REVIEW

1. What two broad classes of safety standards are there?
2. Under what general procedure are "American Standards" developed?

3. Why are "American Standards" valuable?

4. Why should detailed requirements not be included in safety legislation?

5. What groups should be represented in developing safety standards having the force and effect of law?

6. Why is it important to avoid conflicts among the safety requirements of the various states?

7. Why are plant safety rules important?

8. What four essentials should be met in drafting safety rules?

CHAPTER XXVII

Accident Records and Reports

Since all permanent records must be based on accurate information, it is necessary that forms on which original reports of accidents are to be made be designed carefully. These reports must furnish all essential data in such a manner that the accident-prevention engineer and management can interpret and record the information with a view to accomplishing the purposes of the safety program.

What the report should include

In designing report forms, consideration must be given to the following factors:

1. The report should carry information which is necessary to insurance companies carrying the compensation risk and also to government bodies such as industrial commissions and the Department of Labor.
2. The report should require information which will assist the safety engineer to determine the cause of the accident.
3. The report must be sufficiently complete to permit classification of the accident by location and type.
4. The report must present the type of information which will permit a complete analysis of the accident and circumstances surrounding it so that proper measures may be taken to prevent similar occurrences in the future.

Virtually all state industrial commissions require detailed reports covering any injury because of which the worker becomes entitled to compensation under the Workmen's Compensation Act. Laws of different states set the waiting period or the period during which no compensation is payable at from three days to one week. In all cases where the disability extends beyond this waiting period, the general requirement calls for the reporting of the injury on forms approved by the Commission within a certain length of time. In general, Workmen's Compensation Insurance carriers require the same original information on this type of injury as is supplied to the Industrial Commission. These insurance carriers likewise require additional reports involving medical

INDUSTRIAL COMMISSION OF WISCONSIN
MADISON, WIS.

Employer's No.______ (Do not fill in) Accident No.______ (Do not fill in)

COMPLETE this form promptly after injury
[illegible]

EMPLOYERS MUTUAL LIABILITY INSURANCE CO.
1200 Empire Building, Milwaukee, Wisconsin

EMPLOYER'S FIRST REPORT OF INJURY OR DISEASE

IMPORTANT: Copy of this report must be sent by employer **himself** directly to Industrial Commission, State Office Bldg., Madison, Wisconsin, on the fourth day after employe leaves work if disability still continues. In death cases, report must be made within twenty-four hours.

(1) Date of report______ Made out by______ Position______

(2) Employer's name______ Employer is { Individual______ Partnership______ Corporation______

(3) Address______ (Street No.) ______ (City or Town) ______ Telephone No.______

(4) Principal products or business______ (Goods produced, work done or kind of trade or transportation)

(5) Name of your insurance company______ (If "self-insurer" by commission's order, so state) Policy No.______

(6) Where did injury or disease occur?______ (Check) city ☐ village ☐ township ☐ in______ County

(7) Injured Employe______ (Name) ______ (Home address) ______ (Street number) ______ (City) ______ (State)

(8) Age______ (Give date of birth if injured under 19) Sex______ Married?______ Permit on file?______

(9) Occupation______ Length of time worked for you______

(10) Previous physical defects: Eye, Ear, Hernia or otherwise______ (describe)

(11) Under which classification of your policy were his wages carried?______

(12) Date of injury______ (month) ______ (day) ______ (year) Time______ o'clock______ M.

Last day worked______ Engaged in what work when injured?______

(13) Wage rate of employe at time of injury. Per hour $______ Per day $______ Per week $______

Per month $______ (If paid by month) Hours per day______ Days per week______ Piece or time worker______

If piece worker, state his average hourly earnings at time of injury $______

(14) Normal full time employment for injured's class of work. Hours per day______ Days per week______

(15) Employe's earnings in your employ. (a) Calendar weeks worked in past 52 in same kind of work as at time of injury______

(b) Total earnings during such weeks $______ (c) Bonus or premium earned in addition to "total earnings" $______

(16) In addition to above cash wage, did employe receive board?______ Room?______ Tips?______

(17) Is injured an officer, a partner, or a manager?______ If so, state his position______

(18) Are his wages carried on your regular pay roll upon which your policy premium is based?______ Or is he in the employ of a jobber or contractor? (Give Name)______

(19) Did injury occur in the course of his regular employment?______

(20) Describe fully how accident or disease occurred. (Note machine or part, tool, object, substance or thing most directly contributing to the accident or disease, giving special attention to unsafe acts and to the kind of accident as "struck by", "caught in", "burning", "fall", etc.)______

(21) Did injury occur because of (a) Intoxication?______ (b) Failure to use safety devices?______ (c) To obey rules______

(22) Nature and extent of injury. (State exactly the part of the body affected, and the character of the injury or disease)______

(23) If employe has returned to work, state date______ If not, how long will he be away from work?______ Did death result?______

(24) Give name of doctor or hospital______ (Street) ______ (Post Office) ______ (State)

(25) If employe was killed, give the following information as to his dependents, using other side of sheet if necessary:______

______ (Name) ______ (Relationship) ______ (Age) ______ (Address)

(26) Names of witnesses:______

Fig. 1.

expenses, even though the injury may be nondisabling. Some insurance companies also require the reporting of all injuries even though there was no medical expense or loss of time.

It is apparent, then, that in any case of injury where medical expense must be incurred or where a disability is caused, it is incumbent upon the employer to secure sufficient information on the accident so that he can prepare a complete report. These reports, as indicated in Figure 1, carry information relating to the occupation, hours of work, weekly earnings, date of accident, location of accident, accident type, names of witnesses, description of injury, and so on. Within the past few years considerable progress has been made in the standardization of these reports, so that today virtually all information required by the safety engineer for his purposes is made available through the data which must be secured for the insurance carrier or the Industrial Commission. Certain types of accidents will of course occur about which the safety engineer will desire additional information, and provision should be made for supplementary reports in order to complete the record.

Reporting minor injuries

There is considerable disagreement among safety engineers as to the necessity of reporting or recording injuries of a minor nature which cause no disability and require no professional medical attention. When one views this type of injury from the standpoint of cause and the possibility of securing clues as to its prevention, it becomes apparent that even though the accident involved little cost it cannot be ignored in analyzing the possible steps that will lead to prevention in the future. The accident which today results in a minor injury, tomorrow may cause the death of a worker. A sharp tool dropped from an elevated platform may in one case cause no injury whatever because no employee is struck by the tool; in another case it might only slightly injure an employee working below; but in still another case it might cause fatal injuries. Because of this fact, the safety program makes necessary the recording and study of as many accidents as possible, even though some accidents result in only minor injury, or possibly no injury at all.

While it is important that information be secured on as many minor injury cases as possible in order to discover possibilities of more serious occurrences as well as to establish a record in case of future complications arising from a present slight injury, it is likewise true that employees will not make such minor injury reports if a great mass of detailed information is required or if

reprimands or penalties are likely to be inflicted as a result of such reports. In more serious cases the employee realizes the need of a complete report in order to protect his own rights and to guarantee him benefits under compensation laws, which include the payment of his medical bills and the payment of workmen's compensation. No such selfish incentive, however, is apparent to the employee who receives only a minor injury, such as a skin abrasion, or a slight burn, or a particle in the eye.

REPORT OF MINOR INJURY

DATE________________19______

1. NAME OF EMPLOYEE____________________LOCATION______________
2. OCCUPATION____________________DEPARTMENT______________
3. DATE OF INJURY________________19______TIME__________M.
4. DESCRIBE HOW INJURY WAS RECEIVED____________________
5. NATURE OF INJURY____________________
6. NAMES OF WITNESSES____________________
7. FIRST AID RENDERED BY______________DATE__________19______TIME________M.
8. MEDICAL ATTENTION BY DR.______________ADDRESS______________
9. DATE OF MEDICAL ATTENTION______________19______TIME__________M.

CLASSIFICATION NO.______________SIGNED____________________

____
FOREMAN

Fig. 2.

In order to encourage reports on this type of injury, it is suggested that a short form be used such as is indicated in Figure 2. These reports should not be ignored by the safety engineer; they should be studied, and where information which they carry indicates conditions or practices that might result in a serious injury on some other occasion, proper preventive measures should be instituted. In some instances it will be necessary for the safety engineer to request additional information before he can be sure that he has the complete story on this type of accident.

The matter of accident investigation is discussed elsewhere; but it is suggested, in considering the types of reports that should be secured on each accident, that a special report form covering investigation of serious accidents or accidents that might prove serious, be designed. This form should be of such a nature that it will direct the investigating committee's attention to those points which the safety engineer will want to have definitely

established. It is imperative that all available information be secured on every serious accident and on every accident involving the violation of safe practice or safety rules. The analysis of these types of accidents will lead to specific conclusions as to the elimination of hazards.

Who should report accidents

The responsibility for the reporting of accidents should rest on the foreman or the department head. As is true of every operation, the coöperation of the individual making the report should be secured by proving to him that the careful reporting of the facts in each accident case will be beneficial to his operation. Unless the supervisor can see where he will gain some benefit from a careful study and reporting of each accident case, he is likely, in the rush of production, to slight this activity. It is likewise important that the need of such reports be conveyed to all employees through safety meetings, payroll enclosures, posters on the bulletin board, and every other possible means. The requirement that the foreman report all accidents in his department affords an additional opportunity to create a safety consciousness, both among the foremen and the men. The follow-up of accidents by the safety department and requests to the foreman or the individual for opinions on how the accident could have been prevented, or on how future accidents could be prevented, force the participation in the safety program of supervisors and men. This practice will go far toward correcting the idea that is often prevalent that the safety department in itself is responsible for all accidents, as well as for their prevention.

The routine covering the reporting of accidents will vary depending on the size of the plant and its organization. In some instances, these reports will clear through the medical department or the first-aid room. If a full-time industrial nurse is employed, it may well be that the responsibility of handling accident reports is placed with her. In other plants, especially smaller ones, the reports may be routed through the plant organization in the same order that production reports are routed. These reports should eventually reach the desk of the full-time or part-time safety engineer, and the records covering the reports should be maintained by him.

Building up the record

The preceding discussion has concerned itself primarily with the original report of the accident or injury. It is again emphasized that in developing this information care must be taken to

SUMMARY OF ACCIDENT

______ COMPANY. DATE ______ 19__

TYPE OF ACCIDENT ______ NAME OF INDIVIDUAL { EMPLOYEE ______ / PUBLIC ______ }

DIVISION ______

DEPARTMENT ______ FILE NUMBER OUR ______ OTHER ______

REMARKS ______

ACCIDENT COSTS

DATE	DESCRIPTION	AMOUNT	DATE	DESCRIPTION	AMOUNT
				TOTAL	

EMPLOYEE ACCIDENT COMPENSATION COST

DATE	FROM	TO	AMOUNT	DATE	FROM	TO	AMOUNT
						TOTAL	

DAYS LOST - FROM ______ TO ______ NUMBER OF DAYS ______

Fig. 3.

get all of the detail and to be sure that it is correct. The next step is to place it so that it may be used in the future prevention of accidents.

It is desirable that the safety engineer have available at all times a bird's-eye view of any single accident. His record should be so established that at any given time he can immediately obtain from it such information as days lost to date, compensation payments made, cost of medical and hospital expense, and any other information pertaining to this particular case. In order to consolidate this information, it is suggested that each accident report, together with all other matter pertaining to the accident, such as doctor's reports, compensation payment receipts, and the like, be attached to an accident report backing sheet similar to the one shown in Figure 3. This sheet, when the accident case is closed, will provide all essential information for the establishment of the annual record in the department. It will indicate the total time lost, the date of the injury, the date the man returned to work, which doctors were consulted, the number of compensation payments, the cost of compensation payments, and the total cost of the accident.

While of course the purpose of original reports and records similar to the above is to maintain an accurate picture of each individual case, in order that there may be no error in the handling of the case or in the accumulation of costs, the ultimate purpose of maintaining such records goes far beyond the present need. The value of any report depends on the use that is made of the information it contains. Every report should be analyzed in this light. If any information is being called for which is not relevant or which has no particular use, the requirement for furnishing this information should be eliminated. On the other hand, all information that will lead to a determination of causes or to conclusions that will assist in the prevention of future similar accidents should be included with the reports. This information should be of such a nature that it can be used, when combined with other reports, to show trends of frequency and severity rates, types and locations of injuries by departments or plants, causes of injuries, and accident costs. These cumulative records should likewise have a definite purpose and should make possible:

1. The study of causes and location of hazards in order to develop corrective measures.
2. The trend of accidents in each department and the plant as a whole and comparisons of plants and departments.
3. The preparation of concise reports for management in order that it may be aware of the conditions pertaining to safety.

4. The stimulation of added interest among workers.
5. The development of safety rules; the preparation of bulletins, posters, and material for safety meetings.

With this in mind, consideration can be directed toward several types of records and the purpose that may be served by each.

The second type of record that should be established consists of a summary of all accidents. On this record will be entered information pertaining to each accident in sufficient detail so that the record will present an overall picture of the accident situation at any given time. The National Safety Council has designed a form suitable for this purpose, particularly in medium-sized plants.

1943—LOST-TIME ACCIDENTS—1943							
Date	Employee	Div. & Dept.	Injury	Cause	Days Lost	Comp.	Med.

Courtesy National Safety Council.

Fig. 4.

This form is National Safety Council Analysis Sheet for Industrial Injuries, Form IS-2. Larger plants often use tabulating machines or other means of accumulating accident data from the original reports. In small plants a simplified form such as that shown above may be used. It is essential, however, that some type of accident summary which shows each accident that has occurred within a fixed period be kept.

In describing or comparing a plant's safety record, the only cases that are generally used are those involving loss of time from work, that is, accidents causing disabling injuries. Under the American Standard,[1] this type of injury is the only one that is so tabulated. The reasons for this standard of comparison are obvious. Any requirement to include minor first-aid cases or medical cases involving the loss of time in comparative records

[1] "Method of Compiling Industrial Injury Rates."

would be likely to create on the part of employees within a department or a plant an inclination not to report minor injuries. The development of this attitude would defeat the purpose of the comparison. The same situation would without question prevail so far as foremen or supervisors were concerned.

Inasmuch as the relationship between the number of nondisabling injuries to disabling injuries is (for any given plant) in an almost constant ratio, the use of the number of disabling injuries as the measuring stick is sound. Inasmuch as injuries of this type must be recorded and must be made known to the foreman or supervisor and by him to management, because of insurance company and state industrial commission requirements, there is virtually no possibility of distorting the comparison between departments or between plants or companies through failure to report or record all cases.

The continuing accident summary previously mentioned, from which comparative records will be made, should therefore carry information on disabling or lost-time injuries only.

Each disabling injury should be recorded at the time of its occurrence and the remaining data called for on the summary report should be supplied during the course of the case or when the case is closed. With such a record, the safety engineer is in a position to determine at a glance the number of injuries sustained during the year or during the month to date, the prevailing type of accident that is occurring, the total time lost from injury, and the costs of these injuries, at least to the extent of medical and compensation expense.

In many plants a similar record is kept for medical cases only, excluding those involving loss of time. While lost-time cases are not used in computing the plant's frequency rate, a record of them is desirable from the standpoint of accumulating all costs.

While basic records of injuries are obviously important in any organization, often the value of these records is not realized in developing the accident-prevention program. While the records in themselves contain data that must be available for reference in any unusual compensable injury case or wherever information as to the nature of the injury, the amount of time lost, or the compensation paid becomes necessary, other uses are of even greater importance.

From the standpoint of the accident-prevention engineer, the most essential purpose of his records is to make available an overall picture of the accident situation in his plant, in order that he may know where to apply corrective measures and which corrective measures to apply. The record serves the same purpose as does

the case record of a doctor. From X-ray, cardiographs, blood tests, blood pressure, and similar data, the doctor determines the type of treatment required by the patient. From a study of accident frequency, location of accidents, types of accidents, types of injuries, and accident causes, the safety engineer determines his program for treatment. It becomes apparent that the records which he keeps must then be of such a nature as to give this information and in such a manner as will permit its use for the jobs for which the engineer desires it.

Recording the causes

Every safety man should establish a routine method of accumulating and tabulating data which, when summarized, can be of much value. The American Standard Cause Code[2] is designed to organize the essential information pertaining to causes in such manner as to enable coding it for statistical analysis. While coding is obviously worth while only when the mass of accident data is quite large, the selection of accident factors used in the Cause Code will be of value to every safety man.

Under this code each accident is classified according to certain factors. These factors are divided into six major classifications:

1. **The Agency.** The agency which includes the defective object or the substance which is most closely associated with the injury, and which in general could have been properly corrected or guarded.
2. **The Agency Part.** The agency part is considered to be the particular part of the selected agency which is most closely associated with the injury.
3. **The Unsafe Mechanical or Physical Condition.** Under this factor should be shown the condition of the agency which could have been guarded or corrected.
4. **The Accident Type.** The accident type is the manner of contact of the injured person with an object or substance or the movement of the injured person which resulted in the injury.
5. **The Unsafe Act.** Under this heading should be shown the violation of a commonly accepted safe practice or procedure which resulted in the accident.
6. **The Unsafe Personal Factor.** This refers to the mental or bodily characteristic which permitted or occasioned the selected unsafe act.

While in the Code the complete practice is developed to a fine degree, it is so arranged that it can be adapted to small companies as well as large organizations. There are definite advantages in using the Standard practice for compiling accident causes. It has been difficult during past years to secure exact information from industries throughout the country as to accident causes and factors. This difficulty has been aggravated by the fact that no two com-

[2] "Method of Compiling Industrial Accident Causes," published by American Standards Association, 29 W. 39th St. N. Y.

panies used the same means of classifying accidental injuries under the American Standards Association plan. Eventually, most organizations will use the Standard classification, which will permit more exact analysis and sounder conclusions than in the past.

For smaller companies, the National Safety Council has designed a form called "Standard Industrial Injury Report Form," which permits the tabulation of twenty-five injuries on a single sheet with all pertinent data relating to those injuries. The form is designed to follow quite closely the American Standard Cause Code. Experience has proved that the accumulation of this information, either on this particular form or some other simplified form, has been extremely helpful in discovering causes, locations, and types of accidents in the individual plant, and has led to improved methods in the prevention of those accidents. Regardless of the means used, a realization as to the value of analytical data concerning all accidents within a given plant is of prime necessity. If a logical and successful program is to be instituted and continued, this information must be available.

Reports prepared from records

While constant contact with and study of accidents and their causes will convince the safety engineer of the need of certain protective devices, guards, changes in construction or operating practices, or use of protective clothing, it must be kept in mind that other individuals in the organization whose contact and knowledge of injuries and accidents and their causes is limited may not recognize the need of the expenditure of money to reduce the frequency of occurrences of injuries.

It is likewise fundamental that the safety engineer keep management informed of the progress of his efforts, the trend of accidents, the costs of these accidents, and the need of additional expenditures to prevent their recurrence.

For these reasons, the information contained in the records must be compiled for presentation to management including superintendents and foremen, as well as to the men themselves. Engineers do not always have the proper concept of the need of this presentation, nor do they generally have the imagination necessary to present the data in a manner that will serve the purpose for which they are intended. In many cases these shortcomings on the part of the safety engineer can be corrected by securing the assistance of the advertising department or the personnel department of the company in preparing and releasing reports. The presentation made in reports to management or to

men should not in any case be purely statistical. It should be descriptive with pictures, charts, and graphs so that it will present a view of the situation that will sell management or men the idea that the safety engineer has in mind.

Reports to management

Reports on the accident-prevention program should be made to management monthly. These reports should not be too lengthy but they should definitely cover certain items relative to the safety program. Among these "necessaries" are:

1. Frequency.
2. Severity.
3. Total time lost.
4. Costs of accidents, both direct and indirect.

These figures should be given not only for the company as a whole but also for each individual plant or department. The use of comparative records has an immense psychological value and acts as an incentive to the departments making the poorer record. Such presentations would often convince the foreman or superintendent of the desirability of devoting his attention more actively to the prevention of accidents than he has in the past. The records should likewise show not only comparisons between the departments, but also comparisons between this month and last month, this year and last year.

While top management will generally understand the meaning of frequency and severity and other statistical data included in the report, in presenting similar reports to foremen or to the men, care should be taken to translate these statistics into language or figures that will be understandable. For instance, instead of showing frequency by departments, it is often advisable simply to show the number of man-days worked by the department since the last lost-time accident. (A sample type of report of this nature is shown in Figure 5.)

It has been found of considerable advantage by many safety engineers to include also in this report a brief description of serious accidents that have occurred during the past month, as well as recommendations made for the correction of the causes of these accidents.

The use of charts and graphs should not be neglected. (A typical chart is shown in Figure 6.) These charts can be designed to show accident trends, comparisons between various depart-

NO ACCIDENTS RECORDED IN NOVEMBER LET'S FINISH THE YEAR WITHOUT ANY MORE

November 30, 1942

Division	Month of November		Year to Date from January 1		Last December	Total for Year of 1941
	1942	1941	1942	1941		
N. B. & Merchandise	0	0	0	0	0	0
Acctg. & Stores	0	1	0	1	0	1
Menominee-Marinette	0	0	0	1	0	1
Wisconsin Valley	0	0	0	1	0	1
Power	0	0	1	4	0	4
Oshkosh	0	0	2	1	0	1
Sheboygan-Manitowoc	0	0	2	4	0	4
Green Bay	0	0	4	0	0	0
Total	0	1	9	12	0	12

AVERAGE MAN DAYS AND DAYS WORKED SINCE LAST LOST TIME ACCIDENT

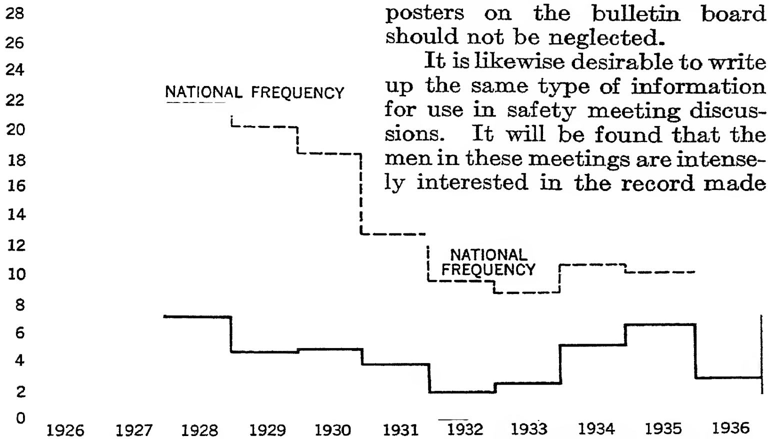
	Days	Man Days
Electric Depts.		
Tomahawk	4547	26,522
Waupaca	4195	32,800
Rhinelander	4042	62,392
Antigo	2972	43,060
Northern	2043	34,828
Minocqua	1557	24,652
Chilton-Brillion	1518	18,682
Merrill	1202	16,204
Stevens Point	915	12,953
Wausau	515	20,085
Menominee-Marinette	479	11,641
Manitowoc	476	8,568
Peninsular	161	3,542
Oshkosh	123	3,198
Green Bay	60	3,000
Gas Plants		
Stevens Point	2960	29,416
Green Bay	2768	54,266
Menominee-Marinette	2529	26,992
Two Rivers	2502	13,178
Oshkosh	1966	23,592
Sheboygan	257	9,252
Bus Operators		
Green Bay	2880	126,468
Wisconsin Valley	1309	43,101
Power		
Stevens Point Sub.	8790	43,616
Washington St. Sub.	6867	61,469
Power.—(Continued)		
Rhinelander Sub.	6538	26,152
Wells St. Sub.	6163	24,652
Bayside	2764	99,078
Valley Garages	1942	29,455
Hydro Plants	1907	142,424
West. Tr. Const. & Maint.	1632	20,571
Manitowoc Plant	1186	27,704
East. Tr. Const. & Maint.	782	12,268
Oshkosh Plant	572	12,736
Eastern Garages	487	12,481
West Elec. Const. & Maint.	405	2,501
East Elec. Const. & Maint.	402	6,630
West Hydro Maint.	140	700
Gas Distribution		
Menominee-Marinette	5142	59,850
Stevens Point	4086	27,508
Oshkosh	1829	31,282
Green Bay	1467	43,395
Sheboygan	447	12,182
Accounting, Stores & Gen. Office		
All divisions	374	164,386
Merchandise and New Business		
All Divisions	2487	158,337

Fig. 5.

ments, comparisons with national frequency, costs, and so on.

The use of data secured from accident statistics can be broadened almost immeasurably. Many companies prepare monthly reports on their accident situation, which are included in the company magazine. Other companies use the device of a letter signed by the president of the company to the superintendent of each department, pointing out the record of his department during the past month or six months, and either complimenting him on the report or questioning him as to the why of the situation, if the record is worse during the more recent period. The possibility of use of statistical data presented in graphical form in charts or posters on the bulletin board should not be neglected.

It is likewise desirable to write up the same type of information for use in safety meeting discussions. It will be found that the men in these meetings are intensely interested in the record made



Courtesy Wisconsin Public Service Corp.

Fig. 6.

by their own group as it relates to other groups. Every possible avenue of getting this type of information back to superintendents from their employees should be used. This is all a part of the job of maintaining interest in the safety program. It might also be added that from a selfish standpoint it is advantageous for the safety engineer to point out the improvement that is being made from period to period as a result of the efforts being devoted to accident prevention. The successful safety engineer keeps in mind that a program which produces results must have as one of its fundamental principles the interest of everyone from top management to the lowliest worker in stopping accidents. Failure to use original records or the accumulation of data from records for this purpose indicates a weakness in the overall program.

REVIEW

1. What four factors should be considered when designing accident report forms?

2. Why should minor injuries be recorded?

3. Who must accept the primary responsibility for reporting accidents? Why?

4. What is the only valid purpose (beyond the payment of compensation) for accident reporting?

5. Give five values that accident records have?

6. What is the purpose of the "American Standard" Cause Code?

7. What six factors are defined in the Cause Code?

8. What four essentials should be shown in an accident report made to management?

9. Is "frequency" readily understood by workmen? How should the idea be shown to them?

10. To what extent would you use the Cause Code in a plant of 500 employees?

CHAPTER XXVIII

Fire Prevention and Protection

The National Board of Fire Underwriters estimates the average direct fire loss in the United States for the decade beginning with 1930 at $319,000,000 annually. The trend was downward during that period, followed by an increase coincident with the war-caused industrial expansion. The 1942 loss was $314,800,000. The life loss averaged about 10,000 deaths each year.

As a result of these losses, not only has production suffered through the destruction of manpower, but likewise an enormous curtailment has occurred through the loss of useful buildings, machines, production equipment, as well as through the loss of finished products and natural resources so vital to the economic welfare of the nation. These indirect losses run into totals that are difficult to estimate and are virtually immeasurable. Some economists state that a conservative figure to cover these losses would reach over a billion dollars a year. With this picture before us, we cannot fail to appreciate the need of a scientific approach to the problem of preventing fires or extinguishing them in their early phases whenever they start.

The constant danger of fire has made necessary the establishment and maintenance of well-organized fire departments in virtually every community. It has also caused to be created such organizations as the National Fire Protection Association and similar organizations throughout the country. The presence of such highly organized and efficient groups does not, however, relieve industrial management or the safety engineer of the fundamental responsibility for the prevention of industrial fires, the maintenance of fire-extinguishing equipment, and the organization and training of employees for control of fires in their early stages.

While many industries are faced with specific problems of fire prevention and control because of the nature of the operation performed and the material handled, the most frequent causes of industrial fires are quite common to all industries. Virtually all of these causes can be eliminated or controlled. Practically all fire losses can be prevented through the application of sound methods of engineering and through adequate provisions for control in the early stages of fires that accidentally occur in spite of preventive measures.

The ramifications of fire prevention and control methods and procedure are almost infinite. Engineering studies concerning fires and the spread of fires, fire-fighting methods, fire prevention and allied subjects fill thousands of volumes. The National Fire Protection Association has attempted to consolidate authoritative data in a handbook of fire prevention. While this book covers the subject in "compact" form, it still consists of a volume of over 1,300 pages.

Regardless of the vast quantity of information available, it is still possible to gain an understanding of the fundamental principles of this subject and the application of these principles which, combined with sound common sense and a knowledge of individual industrial processes and materials, will go a long way in reducing the possibility of fire loss and the control of personal injuries due to fires. These fundamental principles may be stated briefly as follows:

1. Prevention of the start of fire through construction, arrangement, proper storage of flammable materials, periodic inspections, control of operations and processes, maintenance, good housekeeping, and the elimination of unsafe practices.
2. Prompt discovery and extinguishment of fires in their early stages. Except for the relatively few fires caused by explosive combustions of dusts, vapors, and so on, all fires start in a small way. Included under this subject should be the selection and location of first-aid fire equipment, sprinkler systems, alarm systems, and the organization and training of fire brigades.
3. Limits of spread through sound engineering from a fire-protection standpoint. This study must include types of construction, fire doors, barriers, protection against adjacent fires, and confinement of fires that have started to small areas.
4. Provision and proper maintenance of adequate satisfactory facilities in order to hold at a minimum personal injuries that accompany serious fires.

Every safety engineer can acquaint himself with details of these four fundamentals through careful study of his own plant and organization. The following will present a general survey of the principles and their application. It is impossible to apply these principles in a short treatise of this kind to every hazard that might appear in thousands of industrial plants.

Prevention of start of fire

The first of the four fundamentals has to do with the prevention of a fire before a situation which might cause a loss occurs. Too

often this phase of fire prevention is neglected in favor of the somewhat more spectacular preparation for treatment of fires after they begin. As in the case of any type of personal injury, the first interest of the safety engineer should be to eliminate as many factors as possible that might cause a loss before the loss actually occurs.

Each combustible material will ignite and burn when raised to a certain fixed temperature in the presence of oxygen or air. Some substances have a low ignition temperature and burning may be caused by what would ordinarily be considered safe contacts with heated equipment. Ignition of some substances, wood, for example, may be brought about through an extended exposure to temperatures which ordinarily would not cause burning. These temperatures bring about a chemical change in the composition of the wood, forming charcoal, which will ignite at a lower temperature than the original wood. Care must be taken, therefore, to prevent contacts between highly heated pipes or other equipment and flammable materials.

Explosives and certain gases may be ignited by a single spark applied for only a fraction of a second. Because of the variation in the manner of starting fires, fire prevention must be based on ways and means of keeping any combustible material from reaching its ignition temperature, or if manufacturing processes require high temperatures, in so carrying out these processes that the chemical requisite of combustion, oxygen, is not present in sufficient quantities to cause ignition.

While occasionally a fire of serious proportion starts from some obscure or unusual cause, the great majority of fire causes can be placed under a relatively small number of classifications. The table on page 326, from reports of the National Board of Fire Underwriters, shows that 85 per cent of all losses can be attributed to nine causes. A study of these causes will in general indicate what to look for in efforts to reduce fire hazards, and the proper steps which must be taken to eliminate or reduce these hazards.

Matches and smoking

Over one fourth of all fires are started through the careless use of matches and failure to extinguish cigarette, cigar, and pipe ashes. America has come to be a nation of smokers, and any serious consideration of fire protection must recognize and deal with this hazard.

The first step the safety engineer should take to meet this condition is an analysis of plant and yard locations where smoking or the use of matches would be particularly hazardous. These

areas should then be designated as *No Smoking* areas and signs should be posted plainly so that there can be no misunderstanding. It is imperative that after the areas have been so designated, the rule of *No Smoking* be strictly enforced. The rule should apply not only to workers, but also to foremen, superintendents, managers, and even the president of the company. It should be enforced with the same strictness that the goggle rule is applied at the Pullman Company. No one may enter certain areas of the Pullman Company shops without wearing goggles. If the application of the rule is lax, the purpose of the study and the rule is entirely lost. It takes only one match or one lighted cigarette to cause a serious fire.

TABLE 20

ESTIMATED DISTRIBUTION OF UNITED STATES FIRE LOSSES BY CAUSES—ANNUAL AVERAGE[1]

(Average for 3 Yrs., 1937–1939)

Cause	*No. of Fires*	*Loss*
Chimneys, flues—defective or overheated	66,000	$ 17,000,000
Sparks on roofs	66,000	11,000,000
Defective or overheated heaters	26,000	10,400,000
Rubbish	20,000	300,000
Combustibles near heaters	16,000	4,300,000
Open lights, flames, sparks	9,000	2,000,000
Hot ashes, coals	17,000	3,500,000
Oil burners	8,000	2,700,000
Smoking	91,000	15,300,000
Children playing with matches or fire	19,000	3,000,000
Matches	20,000	3,300,000
Electrical	49,000	24,200,000
Electrical appliances, motors	17,000	3,200,000
Flammable liquids, misc., including home dry cleaning and starting fire	24,000	6,000,000
Torches, welding, cutting, etc	7,000	2,400,000
Films, nitrocellulose	1,000	200,000
Lamps and stoves	18,000	5,400,000
Gas and appliances	4,000	1,600,000
Grease, tar, etc	10,000	2,400,000
Spontaneous ignition	18,000	15,500,000
Fireworks	2,000	250,000
Lightning	27,000	8,900,000
Thawing pipes	1,000	250,000
Sparks from machinery, friction	3,000	2,000,000
Incendiary, suspicious	7,000	8,400,000
Miscellaneous	13,000	5,500,000
Unknown	60,000	100,000,000
Explosions	9,000	5,600,000
Exposure	27,000	12,500,000
Totals	655,000	$278,000,000

[1] These figures are taken from the *Handbook of Fire Protection*, (Crosby-Fiske-Forster) published by the National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts.

In certain plants carrying on unusual operations, it may be advisable to extend the *No Smoking* rule to include the elimination of matches or automatic lighters from the clothing of all employees entering the area. Powder plants, for instance, would fall within this category. It is suggested that at the time *No Smoking* rules are promulgated and about to be enforced, the reason for the rules be explained to the men who must enter these areas. Knowledge of the hazards and the possibility of destruction of the plant and of the employees' means of making a livelihood at the plant should be conveyed to every employee.

In other operations fixed areas may be classed as restricted areas. These areas are those where the presence of highly inflammable and explosive gas creates a catastrophe hazard. In these areas a single spark due to friction between a shoe nail and the floor, for instance, might cause terrific loss of property and life. These restrictions, then, should apply to rooms and areas in manufactured and natural gas plants, plants engaged in gasoline, paint, varnish, or enamel manufacture, or plants where explosive dusts or explosive vapors are present, such as grain elevators, rooms and areas where large amounts of readily combustible materials are stored, and other specific locations where hazardous processes are conducted. In these areas the safety engineer should be certain that light switches are of a vapor-proof type, that motors, light bulbs, fuses, and all electrical connections are so installed that there can be no danger of sparks, and that every precaution should be established to eliminate the possibility of a starting condition.

Here again, it is vital that employees understand why these restricted areas are established. Sound education as to the hazards, the possibility of explosion, and the possibility of serious loss of property and of life will usually create a coöperative atmosphere and will eliminate the necessity of constant policing. If it is necessary to establish *No Smoking* or *Restricted* areas, it might also be well at the same time to designate other areas where smoking is permitted. These areas should be kept as free as possible from quantities of combustible materials and should be equipped with containers for cigarette or cigar butts, burned matches, pipe ashes, and so on.

Housekeeping and waste

Closely related to the starting of fires from matches and smoking is the improper or careless storage of waste material. The combination of poor housekeeping and smoking or use of matches usually sets up ideal conditions for a serious fire.

Good housekeeping demands that waste material that cannot be disposed of immediately be stored under conditions which will (a) reduce the possibility of ignition, (b) reduce the speed of combustion, and (c) limit the spread of a fire that starts. The prompt disposal of such waste material as will not be used is vital. This is especially necessary where the waste is subject to rapid oxidation or spontaneous combustion.

Where material such as rubbish must be stored for extended periods, the storage rooms, wherever possible, should be equipped with automatic sprinkler systems. Care should be taken so that the burning and storing of this material does not interfere with the functioning of sprinkler action. Wherever possible, storage rooms should be isolated either in separate buildings or through the installation of fire walls, fire doors, and other protective construction. It will be found that in many cases the reduction in fire insurance rates and premiums will more than justify whatever expenditures are necessary to eliminate the hazards in connection with storage of waste material.

Small quantities of combustible waste, such as oily rags, lint, oily mops, floor oils, and cleaning compounds should always be stored either in self-closing metal receptacles or in metal cupboards. These receptacles contain materials that will not be used again; they should be emptied at the end of each day or shift. Larger quantities of clean waste rags and other wiping material should be stored in self-closing fire resistive bins. It is preferable from a fire-prevention standpoint, wherever large quantities of this type of material are used, to purchase the material in bales which are less hazardous than is the same material when purchased loose. Packing materials, such as excelsior, straw, burlap, shavings, or sawdust should always be stored in special vaults or storerooms, and if possible the area should be protected with automatic sprinklers.

Another possibility of fires due to poor housekeeping is found in employee clothes lockers. These fires start, as a rule, from spontaneous combustion due to oily rags, or oil-soaked clothing, or the failure of employees to extinguish pipes placed in the pockets of clothes which are temporarily hung in the lockers. Employee education and insistence on good housekeeping through periodic inspections of lockers will do much to reduce this hazard. If new lockers are to be installed, the safety engineer should insist on having lockers of steel construction with solid backs and sides and preferably sloping tops. Here again, the saving in fire insurance premiums will help defray the difference in cost between wood and steel lockers. The same principle applies to storage and supply

cupboards, especially where highly inflammable material, such as oil and paint, must be stored.

Recently, a fire of unknown origin occurred in a flooring plant of a large woodworking establishment in Tennessee. Investigation of the fire brought the statement from a foreman that about 11:00 o'clock he noticed smoke coming from a wooden locker. The locker was forced open and the flames spread rapidly, causing total damage of approximately $350,000. This type of hazard is too often passed over with a shrug of the shoulders. Steel construction of lockers, or if wood lockers are already in use, constant inspection and good housekeeping will prevent this type of loss.

Danger spots

In checking the locations in each plant where fire hazards are present, the safety engineer or inspector should give careful consideration to the following danger spots.

1. Boiler rooms.
2. Shafting and belts.
3. Electrical wiring and apparatus.
4. Special processes.

Boiler rooms. Properly constructed and maintained boiler rooms present virtually no fire hazard, yet many fires originate at this point. Investigation shows that the reason for the start of these fires is usually the storage of refuse, waste, or trimmings in proximity to boilers or to heated pipes or flues. Improper storage of ashes, excess storage of soft coal, particularly in wood bins, the use of wood for stairways, partitions, footwalks over or near boilers, and insufficient clearance between stacks or flues and combustible roofs also have contributed largely to the starting of fires at this location where one would think no fires should originate.

The fire in the military buildings at St. Johns, New Brunswick, in February, 1941, with a loss of over $800,000, was determined to have been caused by faulty flues leading from stoves used for heating. In this fire one life was lost in addition to the property damage. Another fire similarly caused resulted in a loss of $275,000 to a five-story building at Lawrence, Massachusetts, in December of the same year. The control of friendly fires, that is fires that are used for industrial purposes or for heating purposes, must be given careful consideration. In these instances, the fire is already present, and it is essential that it be confined to the areas or to the equipment where it will continue to be a friendly

fire. Careful and periodic inspection of all heating apparatus should be a part of the regular routine of every safety engineer.

Shafting and belts. Shafting, bearings, and belts present continual hazards from the standpoint of fire exposure. Shafting should be checked to determine alignment and general condition. Fires starting at this point are usually the result of overheated bearings caused by poor alignment or lack of proper lubrication, and in many cases the starting condition is aggravated because of accumulations of lint or dust. This type of hazard is particularly present in grain elevators, textile mills, sawmills, furniture factories, and cereal mills. Occasionally a fire is started through material becoming wound around the shafting and rubbing on adjacent walls or hangings. Every precaution should be taken to eliminate contacts between shafting or materials on shafting pulleys or belts and their housings or wood floors or partitions. Provisions should be made to prevent oil from bearings dripping or being thrown on floors, walls, or other flammable material in proximity to shafting or pulleys.

Electrical wiring and apparatus. Many fires are classified as "electrical" in origin. The real cause of this class of fire would be more correctly stated under one of the following heads:

1. Poor maintenance of electrical equipment or wiring.
2. Overloading of wiring or equipment.
3. Improper use of equipment.

Electricity, used properly and properly controlled, presents virtually no fire hazard. Studies of fire causes related to electrical use indicate that the actual spark or heat that caused the fire was the result of an electric arc caused by a break in the insulation, partial grounding of a circuit, poor contacts on switches, poor splices and connections, overheating of electrical equipment due to overloading, temporary wiring improperly insulated, or improper fusing. A limited number of so-called "electrical fires" have resulted through the contact between incandescent lamps and flammable materials. In the last few years, with the great increase in electrical welding, some very serious losses have been caused by fires from sparks or through the heat of such welding.

It is vitally important from the standpoint of fire prevention that every electric circuit be properly fused. Fuses in electrical circuits have a function similar to that of the safety valve on a boiler. Electric wiring either serving lighting circuits or furnishing power for motors is designed to carry a certain load. If this load is exceeded by the addition of new equipment or for some other purpose, the wire that becomes overloaded is caused to heat, and

eventually, if the overload is sufficient or continues long enough, the wire will reach incandescence and of course a fire will ensue. To prevent conditions of this kind from developing, fuses and circuit breakers are placed in the electrical circuit. This type of equipment, if the wiring becomes overloaded, immediately cuts off the current flow at a point below the danger point. While of course this cutting off will cause the lights to go out or machines and motors to stop operating, this minor interruption is much less serious than if some method is used to prevent the fuse or circuit breaker from functioning and a serious fire ensues. The practice of increasing the size of the fuse beyond that designed for the size of the wire in the circuit, or of using coins, nails, or heavy wire to restore service after a fuse has blown, is inviting disaster and indicates on the part of the individual who restores service in this manner a lack of knowledge of the function of the fuse and a serious lack of appreciation of the hazard he is creating. Where fuses continue to fail in any circuit, an electrician should be called to check the wiring and equipment for overloads or short circuits.

Where electrical equipment, switches, or wiring are present in rooms containing explosive gases, vapors, or dust, special vapor-proof equipment must be used to prevent the possibility of sparks. This equipment will include motors of the explosion-proof type, sealed vapor-proof bulbs and inclosures for lamps, non-sparking switches, and so on.

One of the common hazards in connection with the use of electricity is brought about through the use of portable lamps which are not of standard type or, if of standard type, have not been properly maintained. The fire hazard in these cases usually results from a cord which has become defective or through the breaking of a lamp. Connected with the fire hazard is a serious hazard to life, which has been discussed under "Low Voltage Electrical Hazards." Maintenance of portable lamps, as well as of all types of portable equipment, should include careful inspection and maintenance of the flexible cords which are necessarily used with this equipment. No cord that is not approved by the Underwriters Laboratories should ever be used for extension purposes. Neither should any flexible or extension cords ever be used for permanent or fixed wiring. These cords are designed for a certain purpose, and their use should be limited to that purpose.

Special processes. While it is not deemed advisable to discuss at length the great variety of special processes and the handling of highly flammable or explosive materials through which are created specific fire hazards, a number of these processes, with short suggestions as to preventive measures are listed on page 332.

SPECIAL PROCESSES AND PREVENTIVE MEASURES

1. *Spray painting:*	Special booths; ventilation; special equipment.
2. *Welding:*	Protection of near-by flammable materials from sparks, heat.
3. *Dip tanks:*	Detached building; covered tanks; overflow pipes.
4. *Drying and baking ovens:*	Fire resistive area; exhaust fans; blowers.
5. *Dry cleaning:*	Well-ventilated buildings; no smoking; large skylight area; protection against static electricity.
6. *Pyroxylin plastics:*	"Tote" boxes (wood); good housekeeping; storage in vented cabinets or vaults; automatic sprinklers.
7. *Flammable liquids and coal-tar derivatives:*	Storage in tight tanks; proper venting; flame arresters; exclusion of all sources of ignition; use of inert gas instead of air.
8. *Motion picture projection:*	Standard projection booth; closed metal containers for film; no-smoking rules; fireproof storage vaults.
9. *Nitrocellulose film:*	Elimination of all sources of ignition; distribution of stock in small units; storage in fire-resistive vaults properly vented.
10. *Explosives:*	See suggested ordinance of National Fire Protection Association[2] for detailed information on safe methods of storage and handling.

It should be kept in mind that every source of heat is a potential fire hazard when placed in contact with combustible material. The basic principles of safeguarding against fire may be stated briefly:

1. Adequate clearance between heated surfaces and combustible materials.
2. Adequate insulation.
3. Proper design and construction of buildings and equipment.
4. Limitation of quantities of combustible material at any one source.
5. Good housekeeping.
6. Proper maintenance of equipment.
7. Periodic and thorough inspection.

Application of these principles to the individual factory or plant should be made with sufficient freedom to insure recognition of special conditions that relate specifically to the operations or materials under consideration. The prime consideration of the safety engineer or inspector should be the reduction of conditions which might be responsible for the starting of a fire to the absolute minimum. Here in the field of fire protection it is doubly true that an ounce of prevention is worth a pound of cure.

Discovery and extinguishment

Unfortunately, in spite of every effort made to keep fires from starting, hundreds of serious fires occur daily and catastrophes with large loss of life and property occur many times each year. In

[2] Obtainable on request from National Fire Protection Association.

November, 1942, the night club fire at Boston exacted a toll of some 500 lives. A fire at St. John's during the same month took another 100 lives. Many of the men and women killed in these fires were playing vital parts in the war effort and the loss was irreplaceable. In 1940 a mine fire in Pennsylvania cost 63 lives, and a dance hall fire in Natchez, Mississippi, killed 207 people. While some of these fires were not industrial fires, nevertheless, the loss of workers engaged in industry through such fires is high. It cannot be assumed that industrial concerns are free from similar catastrophes and terrible losses. The records of the past several years show that hundreds of employees have been killed in explosions and fires at powder plants, in mines, in processing plants, textile factories, packing houses, gas works, and other manufacturing plants. These high losses of life are in every case in addition to the property and production losses that have previously been mentioned. When it is realized that the average number of fires during each of the last three years has been in the neighborhood of 655,000 or about 1,800 a day, the tremendous loss that necessarily has resulted becomes at once apparent.

These facts are given to indicate the necessity of taking further steps through effort to prevent fires; that is, steps to control fires at the start when the control is simple and to set up programs that will limit the property loss and loss of life when a serious fire develops.

Virtually all industrial plants are located in areas which are accessible to organized fire-fighting equipment maintained by the community. Too often, however, industrial management has neglected to coördinate the plant activities with the program of the organized fire department. This lack of coöperation between industrial management and fire-protection authorities has allowed innumerable small fires to become large fires with consequently higher losses. A clear understanding of the function of the community fire-extinguishing organization on the part of the management, and the organization and training of plant personnel for fire fighting in coöperation with city fire authorities, would help prevent many of these losses. It is the responsibility of management to advise and plan with the local fire department in order to assure prompt and proper action in case of an emergency. The safety engineer should assume this responsibility and develop with the local authorities a plan of action that should cover the points (a) special hazards, (b) access to premises, (c) coördination of plant and public protection, and (d) inspection.

Special hazards. The fire department should be advised of special hazards which exist in the individual plant in order that

proper equipment, such as chemical apparatus, fog nozzles, and so on, may be available when they are needed. This information is likewise necessary in order that the firemen can be trained to combat according to scientific methods and procedures the types of fires that will result from the hazards involved.

Access to premises. Plans should be developed with local authorities so that fire equipment will have quick accessibility to the point of the fire in any emergency. Many cases are on record where fires that have occurred at night have spread rapidly because the fire department was unable to get into the yard through gates which, though open in the daytime, were locked securely at night. Before entrance could be secured it was necessary for the department, in cases of this kind, to break down the gate or the fence, thus consuming vital minutes which could have been utilized effectively at the start of the fire. Other cases have arisen where the department equipment while gaining entrance to the yard was unable to make turns at crossroads within the yard due to the piling of material close to the corner. It is too late when the fire occurs to remedy situations of this kind, and the safety engineer should plan with the local authorities so that prompt entrance to the premises can always be made. A survey should be made within the plant itself for conditions that would prevent firemen from approaching the fire promptly. The survey should be of such a nature that it will assure clear passageways, unlocked doors, and if possible emergency lighting so that there will be no question of approach to the fire when it occurs. All of these matters should be discussed with the local fire people or someone else in authority to make sure that there is perfect understanding prior to the emergency.

Coördination of plant and public protection. Fire brigades should be organized within the plant and first-aid fire-fighting equipment, such as portable extinguishers, fire buckets, and hose should be purchased. The location of standpipes and fire-alarm systems should always be planned in coöperation with the local fire department heads so that the greatest efficiency may be obtained through correlating the functions of plant and public fire-extinguishing equipment.

Inspection. Inspections by representatives of the local fire department should be invited and suggestions made by the inspectors should be followed wherever possible. Too often management resents these inspections, not realizing that the purpose of the inspection is to save the management money and prevent catastrophes through scientific planning for protection.

All of these things must of necessity be done before a fire starts. Fires, like accidents, often happen at the most inopportune times. They are not foreseen, and many times activities that are necessary when they do occur have not been planned sufficiently to prevent serious results. One of the most important functions of the safety engineer is to set up a fire-prevention and extinguishment program, and to be sure that his program is coördinated in every respect with the program and activities of the community fire department.

Fire alarms

Each year many fires discovered in their early stages become uncontrollable and cause hundreds of thousands of dollars in damage through the failure of the individual who discovered the fire to sound a proper alarm promptly. At Memphis, Tennessee, an employee in a large plant after discovering a fire ran to the boiler room to get help instead of sounding a manual alarm which was available. In his excitement he failed to call the local fire department, and no one else called the department until the fire had spread and had reached serious proportions. At Canton, Massachusetts, employees who discovered a small blaze shut off the sprinkler system in order to prevent water damage and attempted to fight the fire with small hand extinguishers. When the fire reached proportions that were beyond the control of the few employees present, someone turned in an alarm. Twenty minutes had elapsed between the discovery of the fire and the turning in of the alarm. By the time the fire department arrived, the plant was an inferno. Property damage alone amounted to almost $2,000,000. The damage done to the country's production facilities for rubber are inestimable.

The first principle of efficient fire fighting, then, is to turn in the alarm as soon as the fire is discovered. This applies to both the plant alarm system and the public alarm system. It is far better to turn in an alarm and then have the fire under control at the time the department arrives than to fail to turn in the alarm and have a fire that even the department cannot extinguish.

Because of general uniformity in the type of public alarm systems, it is sufficient here to suggest that a public fire alarm box or, in large plants, a number of such alarm boxes be located where they can be reached quickly. Every employee should know how to "pull the alarm" in these boxes and should be instructed that in case of any fire, regardless of size, the alarm should be sounded immediately.

The plant alarm system is, of course, of prime importance, both from a standpoint of property protection and of human lives. The essentials of an effective alarm system are briefly:

1. A reliable signal must be transmitted.
2. It must reach those who are trained for fire protection, regardless of where they are located in the plant.
3. It should be used for no other purpose than to sound the alarm for fire.
4. It should, if possible, indicate the location of the fire.
5. If an individual must be depended on to transmit notice of fire, the means of transmission must be readily accessible and should require the simplest possible performance.
6. The alarm should be sufficiently loud so that everyone can hear it, and of such a nature that everyone will recognize it.

There are a number of different types of alarms, any of which may be suitable for any type of plant. The most common alarm systems are those that are manually operated. That is, the sounding of the alarm depends on the action of some individual who has discovered the fire. These alarms are generally sounded by the pulling of a lever, the blowing of a whistle, or the sounding of a gong.

A more desirable type of alarm is that which is automatically sounded when high temperatures develop in the vicinity. These alarms are generally divided into two classes: the fixed-temperature type, which is designed to operate at a predetermined temperature, and the rate-of-rise type which is designed to operate when the rapidity of temperature rise exceeds a certain predetermined rate. The advantage of automatic alarms is immediately apparent. There is no possibility of failure to have the alarm sounded because of excitement or poor judgment. Neither is there danger of a fire becoming uncontrollable because no employee happens to be in the vicinity. The automatic alarm does not require presence of mind on the part of an employee, or even the presence of an employee. Certain problems, however, are involved in the installation of automatic alarms. These problems are related to the proper location of the alarms to assure functioning, and adequate maintenance to assure dependability. In some plants where the hazard of fire is great, all automatic signaling devices are located near the point of most serious hazard. The safety engineer, through a study of his own plant and operations, can determine with a considerable degree of accuracy the points where these alarms should be placed. Here again the coöperation of authorities is desirable.

Control of fires in early stages

While emphasis has been placed on the necessity of sounding a prompt alarm in the case of fire, it is not intended that this should be the only step taken toward its control. Much can be done to keep starting fires under control prior to the arrival of the fire department through the intelligent use of available first-aid fire-fighting equipment and proper training of personnel. In order to provide the proper equipment, it is necessary that there be a thorough understanding of the possible types of fires that may originate at any point in the plant, and a knowledge as to the correct type of extinguishing equipment to meet the hazards caused by these fires. This having been determined, care should be taken to so locate the extinguisher selected that it will be available to employees who are present immediately on discovery of the fire.

Virtually all fires start as small, localized flames. The function of plant fire-extinguishing equipment is to extinguish this starting blaze immediately if possible or to confine it to a small area in order to make its extinguishment comparatively simple on the arrival of the organized fire department.

With this function in mind, it is possible to determine the type of extinguisher that should be made available at each specific location in the plant. If, for instance, the possibility of oil fires is present at certain locations, then the extinguisher to be placed near this point should be of the type that is designed specifically for oil fires. While other types of extinguishers might be of some help, they would not be adequate to keep such a fire under control, because different types of fires require different types of extinguishers. Studies have been made by laboratories[3] maintained by the fire underwriters, and through these studies fires have been classified. These classifications are based on the types of extinguishing agents necessary to combat specific types of fires.

Class A fires. Under this classification are fires that occur in common combustible materials such as wood, paper, rags, and allied material. Fires of this type can be readily extinguished by water or solutions containing large amounts of water. The process of extinguishing this class of fire depends primarily on the cooling and quenching effect of the water.

Class B fires. Under this classification are fires where a blanketing effect, which will exclude oxygen, is necessary for extinguishment. Water should not ordinarily be used to combat

[3] Underwriters Laboratories, Inc., 207 E. Ohio Street, Chicago, Illinois. Associated Factory Mutual Fire Insurance Companies, 184 High St., Boston, Mass.

this type of fire. Quite often water would tend to spread the blaze rather than control it. Fires which fall into this classification are oil fires and fires of inflammable liquids such as gasoline or grease.

Class C fires. Class C fires are those that occur in electrical equipment, or in equipment that is in close proximity to electric circuits. Here care must be taken to use a nonconducting extinguishing agent in order to protect the individuals who are fighting the fire. Examples of this type of fire are transformer fires, switchboard fires, and motor and generator fires.

There are numerous styles and makes of first-aid fire appliances which are suitable for each class of fire. To list all of the types of extinguishers would take considerable space, but a brief summary of some of those commonly used for each class of fire is given.

Class A Fires

Fire Pails (12 quart)	Calcium Chloride (2½ gallon)
Soda Acid (2½ gallon)	Foam (1½, 2½, 5 gallon)
Pump Tank (2½, 5 gallon)	Carbon Dioxide Cartridge—with plain water (2½ gallon)

Class B Fires

Foam (1½, 2½, 5 gallon)	Carbon Dioxide Gas (2 lbs. to 20 lbs.)
Vaporizing Liquid, pump type (1 quart to 2 gallon)	Dry Compound (7½ lbs. to 20 lbs.)
Vaporizing Liquid, stored pressure type (½ to 3 gallon)	

Class C Fires

Same as Class B, with the exception of foam.

Too much emphasis cannot be placed on the advisability of consulting with the state or local Fire Insurance Rating Bureau as well as the local fire department before purchasing fire extinguishers. After the extinguishers have been purchased, the local fire department should again assist in determining the correct location for the placement of the extinguishers. Many factors must be considered in locating an extinguishing agent, and only those who have had adequate experience in fire fighting can give sound advice on this point. The problems are so complex that it would be unwise for anyone without wide experience to attempt to give such advice. There is another reason why the state Fire Insurance Rating Bureau should be called into the picture at this point. Fire insurance rates, which determine the premium to be paid for fire protection, are based not only on the hazard that exists but also on the protection that is available. While industrial management might feel that from their own standpoint certain protection is sufficient, it is possible that the rating bureau would allow no credit for this protection because of past experience,

which might have indicated that this protection is not entirely suitable. The expenditure of the same amount of money for other equipment might conceivably result in savings in fire insurance premiums which would more than pay for the equipment.

Construction, operation, inspection, and maintenance of extinguishers

Soda acid extinguishers. This type of extinguisher is generally made to hold $2\frac{1}{2}$ gallons. It consists of an outside shell and is so designed that, when tipped over, an acid, usually sulphuric acid, is released and combines with a solution of bicarbonate of soda in water. The chemical reaction produces sodium sulphate dissolved in water plus large quantities of carbon dioxide gas. The generation of carbon dioxide expels the water solution through the hose connected to the extinguisher.

The soda acid extinguisher should be recharged annually as well as immediately after use. Before recharging, all parts should be washed thoroughly with water and the water should be drained through the hose. In refilling, the bicarbonate of soda should be thoroughly mixed with the water so that there cannot be any deposit. It should be kept in mind that this type of extinguisher is subject to freezing and therefore must not be located at any point where freezing temperatures may develop. In no case should any antifreeze solution be used in the extinguisher; it is possible that the use of such a chemical would prevent the action necessary to generate carbon dioxide in an emergency.

In using the extinguisher it should be carried upright to the scene of the fire and then inverted. Many cases are on record where an employee has seized such an extinguisher and tipped it sufficiently to spill the acid, thereby causing a reaction through which all of the water in the extinguisher has been discharged prior to getting it to the scene of the fire.

Pump tank extinguisher. The pump tank type of extinguisher uses either plain water or an antifreeze solution usually made by dissolving calcium chloride in water. The extinguisher consists merely of a shell to which air has access and a pump attached to a hose and so designed that when operated the extinguishing liquid will be discharged through the hose. This type of extinguisher has certain distinct advantages. Its capacity, while generally $2\frac{1}{2}$ or 5 gallons, is virtually unlimited because it can be filled while in use by a second employee merely emptying pails of water into its top.

When checking this type of extinguisher it should be examined particularly as to the condition of the parts of the pump to make

certain that it will function in an emergency. Generally a drop of oil should be placed on the piston rod packing at the time of inspection. It is also recommended that the extinguisher be washed thoroughly and the water drained through the hose at least once each year.

Calcium chloride extinguisher. The calcium chloride extinguisher generally comes in the $2\frac{1}{2}$- or 5-gallon size. Usually the extinguishing agent is an antifreeze solution. This solution is expelled in most extinguishers by a cartridge containing carbon dioxide under pressure. Other types of calcium chloride extinguishers are actuated by an acid reaction. The maintenance of these extinguishers is rather simple, but they should be discharged and recharged annually.

Vaporizing liquid extinguishers. These extinguishers generally use commercial carbon tetrachloride. The small hand sizes run from 1 to 2 quarts, whereas larger sizes carry as high as 2 gallons of liquid under pressure. The hand type depends on pump action to expel the liquid. The larger types depend for their action on air pressure, which is constantly maintained on the liquid.

These extinguishers should be inspected at least once each year, and should be checked more frequently to make sure that the liquid has not been lost either through mechanical defect or unauthorized use by employees. In checking the extinguisher, the liquid should be discharged into a pail or bucket to determine whether or not the pump is in working order, and following the discharge the liquid may be poured back into the extinguisher. The liquid is rather costly and should not be wasted. It is not wise to use commercial liquids, but only liquids manufactured for use in fire extinguishers. Small amounts of water or other impurities are likely to cause damage by corrosion. These extinguishers have the advantage of being virtually nonfreeze and adaptable for many varied uses. The extinguishing agent, in contacting a fire or high temperature, evaporates rapidly and forms a smothering vapor. Care should be taken when using this type of extinguisher in closed areas where the ventilation is bad. The vapors of these liquids are toxic. Also a toxic gas forms under certain conditions and the effects of the gas can be very serious on persons using the extinguisher or otherwise exposed unless sufficient ventilation is present.

In maintaining this type and also other types of extinguishers, it is advisable to seal the extinguisher either with a wire or metal or with special tape provided by the manufacturer. This precaution will prevent the unauthorized use of the liquid and will also prevent individuals with ulterior motives from placing other liquids in the extinguisher. The presence of the seal permits a quick

check by visual inspection to determine whether or not the extinguisher has been used.

In the above discussion only a few of the more common types of extinguishers have been covered. Many other types, most of which are designed for specific purposes such as oil fires or electrical fires, are available. Information on these extinguishers can be secured from the National Fire Protection Association or the Fire Underwriter's Laboratories. For prompt information the local fire department should be contacted.

Automatic sprinklers

The automatic sprinkler is the most important of all fire-protection devices. It is estimated that over fifty billions of dollars worth of property in the United States is protected with this type of equipment. The loss of sprinklered property compared with that of unsprinklered property is remarkably low. Some authorities estimate that an annual saving of two hundred million dollars results because of sprinkler systems. The same situation exists in regard to the saving of life through these automatic protective devices.

Under proper conditions, a carefully designed and installed sprinkler system will either completely extinguish a fire that starts or so control it that its extinguishment is a simple matter. Occasionally, however, a sprinkler system fails to function. In some such cases, it has been discovered that the water was shut off either through an error or some inadvertent act of an employee. In other cases it has been found that the sprinkler system did not operate because the sprinkler head had been enclosed in some manner, either deliberately or through the piling of material in close proximity to it. Under certain conditions, the sprinkler system will not function adequately. For instance, a sudden flash fire caused by combustible dust or inflammable vapors may create too widespread a fire for the system to control. Explosions of powder or other material through their violence may make the sprinkler system inoperative.

The automatic sprinkler is based on the principle of providing a spray or shower of water released on the fire itself at any point where a fire starts and in the early stages of the blaze. In most sprinkler systems, water is supplied through piping generally attached to the ceiling with sprinkler heads spaced along the pipe. Each head consists of an orifice which is closed by a disc, the disc being held in place against the water pressure by a device that releases at a predetermined temperature through the fusion of

solder, of a chemical, or the breaking of a bulb caused by the expansion of liquid contained within it.

The sprinkler head also is so designed that when water is released it will be distributed over a substantial area in the manner necessary to extinguish any fire that is present. Sprinkler systems to be used in any building should be designed by expert engineers who understand this phase of fire protection, and their operations should be explained by these men. Certain high-hazard conditions require certain types of sprinklers, while normal hazards can be protected through ordinary systems.

It is vital that sprinkler systems be maintained with a high standard of efficiency. The maintenance should be placed directly under the supervision of some individual who understands the purpose and the operation of the system. Tied into the system should be an alarm so that, simultaneous with the release of a sprinkler head, notification will be given to the fire department or other personnel of the presence of a fire.

Fire hose systems

Fires that are not extinguished either by sprinkler systems or first-aid appliances in their incipient stages become large and require great quantities of water to prevent further spread and to secure ultimate extinguishment.

While dependency must be placed on community fire departments for the handling of large fires, availability of fire hose attached to outlets throughout the plant is of first importance in the reduction of the fire hazard.

Care must be taken in the selection of hose couplings and nozzles, in the proper location of outlets. In purchasing hose, the advice of the local fire department or state Fire Inspection Bureau should be followed. The hose should always carry the label of Underwriters' Laboratories to insure proper functioning under pressure.

In general, rubber-lined hose should be used for outside protection, while unlined linen hose is most suitable for inside use. Most fire departments recommend hose not exceeding $1\frac{1}{2}$ inches in diameter because of the difficulty inexperienced men have in handling larger types. Should larger hose be purchased, men must be trained in its use. A recent fatal accident resulted when a man was thrown off the roof of a building by the whip of the hose when the water was turned on.

Hose of any type should be stored so that it is quickly available in case of fire. There are a number of types of storage devices, the use of which will accomplish this purpose and will likewise

keep the hose in good condition when it is not in use. Reels, swinging racks, and carts are available for this purpose.

The life of good hose varies from a few years to possibly 10 years, depending on the care given it and the protection from dirt, injurious chemicals, gases, and so on. Hose is generally damaged by mechanical injury or through contact with heat, oil, acid, or gasoline. It must also be kept in mind that linen hose may be damaged through mildew, and provisions should be made to prevent this type of injury. Maintenance of hose requires constant and thorough inspection and care. The hose should be checked periodically, changed on the reel or rack several times each year, dried thoroughly after use and before storage, and washed or brushed after exposure to dirt or oil. It should, of course, likewise be protected from mechanical injury both while stored and while in use. Rubber-lined hose should be tested several times a year. Unlined linen hose should not be wet except when needed for fire protection. More damage can be done to this hose through wetting and insufficient drying than through continued dry storage. Careful inspection will help maintain linen hose in serviceable condition.

Couplings

It is vital that all hydrant nipples and hose couplings be standard. (American standard is $2\frac{1}{2}$-inch fire hose thread.) Hydrant and hose equipment couplings, to serve their purpose, must be interchangeable. Many times every year hose has been made useless in emergencies because, at the time of attempting to connect the hose to the hydrant or to fit couplings, it has been discovered that errors in purchasing equipment or design of equipment have been made. Here again contacts should be made with the local fire department to determine whether the couplings and connections of public equipment and private systems are uniform. If it is found that variations are present, adapters should be secured before the equipment is needed at a fire.

The preceding discussion of fire equipment and apparatus has given consideration only to types of equipment designed for conditions usually existing. Special hazards often require special equipment. The mere presence of extinguishers, hose, or other equipment does not afford full protection against serious fires. Many cases are on record where uninformed employees have made available equipment ineffective because of lack of knowledge as to how the equipment should be used. It is essential that all employees have an understanding of the various first-aid fire-protection equipment and, wherever possible, training in its use.

In many plants one entire safety meeting each year is devoted to a display, description, and demonstration of the use of the various types of extinguishers located in each department. Where the extinguisher must be discharged in order to check its condition, discharge under actual conditions of use should be made.

It has been deemed wise by many safety engineers to seal all extinguishers after inspection in order to prevent tampering with the mechanical equipment or discharge of the extinguisher for purposes other than fire. The sealing offers a positive means of visual check, because, whenever a foreman, a member of the safety committee, or a superintendent finds that a seal has been removed or broken, he immediately recognizes the need of checking and refilling an empty extinguisher. Time lost in attempting to get an ineffective or damaged extinguisher to work, or even in getting it to the fire, could be better utilized for other purposes.

Fire brigades

In larger plants it is desirable to have trained groups or fire brigades to handle equipment and to take charge of the situation when an emergency due to fire arises. Even in small plants a few men can be given complete instructions as to fire hazards, use of equipment, and procedure in case of fire.

The work of fire brigades in larger plants depends on many factors which are related to the physical arrangement of the plant, the size of the plant, and the type of operations. Regardless of the size of the plant, however, it should be recognized by management that the fire brigade and fire protection is an important part of the plant's operation.

Certain fundamental essentials must govern the work of any fire-fighting group, if it is to be efficient. First, rigid discipline must be established within the group itself. Second, the group must be provided with necessary equipment which is maintained in usable condition. Third, the group must be trained uner discipline in the use of the equipment and in the fundamental principles of fire fighting. The strength of the brigade, the amount of equipment, and the frequency of fire drills will depend almost entirely on the size of the plant and the nature of the hazards.

The men selected as members of the brigade should be intelligent, level headed, and able bodied. Generally the foreman or superintendent, or some other person whose authority is recognized and who has a thorough knowledge of the plant and operations, should be selected as chief. This man should have the respect of all members of the brigade and should have had specific

training in fire fighting, fire protection, and the use of equipment. A unit or a brigade should be a part of each work shift.

Every man on the fire brigade should know the location of each piece of fire equipment. He should be assigned specific duties in case of fire. Those duties will be dependent on the nature of the equipment available, the size of the plant, and the type of hazard. For instance, where hose is available, hose men, nozzle men, and hydrant men should be trained. Other members of the unit should be trained to direct the exit of employees, still others to use the chemical extinguishers, and so on. It is generally desirable to select men for this work who live near the plant. The value of the brigade will be proportional to the promptness and efficiency of each member under emergency conditions. It is, therefore, imperative that every individual in the unit have periodic instruction and practice in fire drill and fire fighting. Constant drilling cannot be overemphasized. The drilling and instruction can in many cases be done best by the chief or other officer of the local fire department. Not only will this procedure guarantee the proper training, but it will likewise develop full coördination between plant and city departments in case of fire.

Prevention of spread of fire

One of the fundamental objectives in fire fighting is to confine the fire that has started to as small an area as possible. Because of this fact it is essential that those who are charged with fire protection and extinguishment have some knowledge of how fires normally spread.

Ordinarily, fires spread in three ways. The most rapid means of spread is usually upward from floor to floor of the same building. Second, under certain conditions fires will spread from one part of a building to another part or from building to building where they adjoin each other. Under adverse conditions such as high wind, sudden explosion, close proximity, and so on, fires often spread from building to building not adjoining.

Consideration should be given to the check of fire within single areas. In considering the prevention of the most common type of spread, from floor to floor, careful examination should be made of floor openings such as those for chutes, elevators, stairways, dumb waiters, beltways, pipes, and light wells. Where such openings are present, and where the hazard of fire is great, provision should be made for the openings to be automatically closed in case of fire. The use of fire doors which are automatically operated by heat is the accepted method of closing such openings.

It should be kept in mind that in many cases, while the fire itself may not pass from a lower to an upper floor through any of these openings, the heat generated by a fire will cause a rapid rise of extremely hot air to upper floors unless some means is provided to prevent such a rise. The temperature of these hot gases or heated air is often-times well above the ignition point of materials on the upper floors. Many cases are on record where a fire, having started on one of the lower floors or in the basement, has caused a fire several floors above without any flame between the floors. It is, therefore, not just the spread of flame that must be considered, but the rise of gases that will cause explosion or fire at other locations.

Fire likewise will search out any weak spot in building construction, such as thin sections of flooring, cracks between floorboards, or openings caused by shrinkage. In case of a fire on any floor, a check should be made to be certain that the fire has not made progress and has not found its way into the concealed construction of the building. Many times fires that have presumably been extinguished break out some time later because of lack of thoroughness or lack of understanding on the part of those who extinguished them.

Another means of fires passing from one floor to another is through external windows usually located one directly above the other on successive floors. This is particularly true where windows on the upper floor are not protected or are open at the time of the fire. The best protection against this hazard is to use windows of wired glass in steel sash in all stories of the building. While it is true that a fire may destroy such windows on the floor it is located on, it is not likely that windows of similar construction on the floors immediately above will be damaged.

While fire normally spreads quite rapidly within the building where it begins, under some conditions the spread will be from one building to another building which is adjoining. In congested areas, one wall often separates two buildings; and in many cases where there are two walls, these walls are in contact. In such cases, fires pass from one building to another, either through unprotected divisional wall openings, through the failure of fire doors, through fire doors partially or improperly equipped with hardware, over roofs or around ends of walls, or by heat passing directly through the single wall. In rare instances, a smoke explosion within the burning building may cause fires in adjoining buildings.

A few suggestions can be made for protection against the spreading of fire in the manners indicated above.

1. Where openings in walls are not necessary, they should either be closed permanently through heavy fire-resistive doors or be bricked up.

2. If fire doors are used to protect such openings, they should be placed on each side of the wall so as to give two lines of defense with valuable air space between. It is not sufficient to place but one fire door, as this will in many instances permit the spread of fire, especially if the entire building on one side of the door is consumed.

3. A careful check should be made to be certain that fire doors close properly and that the doors, sills, door frames, and so on, are of such construction that they will not convey fire under extreme heat conditions.

4. Where large values are involved, it may be desirable to extend the division wall between buildings through the roof in order to form a parapet, especially if the roof is combustible on both sides of the wall.

5. In buildings of ordinary height, additional protection against spread of fire can be secured through the protection of windows with fire-resistive frames and wire glass.

While the possibility of fire spreading from building to building where buildings are not adjoining is not as great as the spread from other causes, there are still many opportunities for the development of a fire of considerable extent and one that will involve numerous unconnected buildings. Generally speaking, such fires develop from the dropping of burning embers or other burning material onto combustible roofs of near-by buildings. Where roofs are made of asbestos cement, slate, tile, or metal, this possibility is of course reduced to a minimum.

A building near by the burning building often catches fire through the heating and breaking into flame of combustible cornices. Wherever possible, such cornices should be removed. If they cannot be removed, the hazard can be reduced somewhat through the covering of such cornices with lock-jointed tin or metal lath and plaster.

The exposure presented by combustible exterior walls is a serious one. Such walls may heat to the ignition temperature from fires within 15 or 20 feet, and even greater distances where the fire is a severe one. While local fire departments can do much to prevent the spread of fire to buildings not directly adjoining, many buildings so located, especially in hazardous areas, are protected with outside sprinklers. In some cases, walls have been covered with metal lath and plaster in order to reduce the hazard further.

Exit facilities

The protection of property is of course of great importance in considering fire hazards. From the standpoint of this text, however, we are more concerned with the protection of life. It is for this reason that we are giving special attention to the subject of exit facilities. Records indicate that large loss of life in fire is due primarily to failure to provide sufficient means for occupants to leave the building under emergency conditions. It is suggested that the Building Exits Code developed by the National Fire Protection Association[4] Committee on Safety to Life be consulted in order to determine whether exits in any building or plant meet with the requirements for the protection of life under emergency conditions.

As a quick check list, the following suggestions pertaining to exits are given:

1. Emergency exit needs depend on the construction of the building, the fire hazard of the materials or processes housed, the fire protection provided, and the characteristics of its occupants. Actually, however, it is not practicable to vary exit requirements much. In general, the practical viewpoint is to provide exit facilities adequate to meet the worst probable combination of circumstances.

2. The possibility of panic should always be taken into account. Panic can occur without fire. Conditions likely to cause blocking in case of a panicky rush should be avoided (narrow exits, narrow sections or sharp corners in passageways, winders and narrow landings in stairs, inadequate spaces at foot of stair flights or at exit discharge).

3. The provision of two exits so located as to render the cutting off of both at one time extremely improbable is fundamental to safety. This principle should never be violated in areas where any considerable number of persons congregate for any purpose.

4. Free travel of able-bodied persons in single file requires a width of 27 inches, which is for that reason used as the unit of exit width. A two-unit width is the minimum acceptable as satisfactory practice, though building codes commonly accept narrower widths for light occupancy in existing buildings.

5. Maximum travel distance from any point in a workroom or area to reach the nearest exit should not exceed:

[4] Also approved by ASA as American Standard.

High-hazard occupancy	75 feet
Moderate or low-hazard occupancy	100 feet
Moderate hazard sprinklered	150 feet

(*High-hazard* is defined as having contents likely to burn with extreme rapidity, or to give off poisonous fumes, or to explode.)

6. Exits should be readily accessible, unobstructed, the path of escape unmistakable and suitably lighted.

7. The minimum allowable clear stair width is 44 inches; tread width, exclusive of nosing, not less than 9 inches; riser height, not over $7\frac{3}{4}$ inches. Treads and risers should be uniform in width and height and so proportioned that the sum of two risers and a tread, exclusive of nosing, is not less than 24 inches nor more than 25 inches.

8. Stairways should be enclosed in fire-resistive walls with openings protected by fire doors.

9. All doors in exits should open in the direction of egress with the exception of sliding doors, which are permissible in horizontal exits through fire walls between sections of a building.

10. Outside fire escapes should consist of stairs substantially in accordance with the requirements for inside exit stairs. Unless so placed or protected that flames or smoke from windows or other openings cannot cut them off, they are of little value and may constitute traps instead of means of escape. The ordinary outside fire escape is not recognized as a safe means of egress in new buildings.

11. The rope or individual types of escapes or ladders are of value only for vigorous persons trained in their use.

12. Slide escapes properly maintained are useful for personnel under good control and drilled in their use.

13. Revolving doors and elevators are not desirable for emergency exit purposes.

14. Ramps having maximum slope of 1 foot in 10 feet are acceptable in lieu of stairs.

REVIEW

1. What was the approximate property and life loss from fire in the United States during 1942?

2. What are the four fundamental principles in reducing fire loss?

3. What is the biggest single source of fires?

4. Why is bad housekeeping a major factor in fires?

5. What is the principle of the automatic sprinkler?

6. What "danger spots" should the safety engineer give special consideration to?

7. What four points should be taken care of in arranging for coöperation with the outside fire departments?

8. What are the essentials of an effective fire-alarm system?

9. What are the three classes of fires?

10. What kind of extinguishers are used in each?

11. What is the principle of the soda acid extinguisher?

12. What is the hazard of the vaporizing liquid extinguisher?

13. What are the three essentials of an effective fire-fighting group?

14. How often should fire extinguishers be inspected thoroughly?

15. In what ways do fires spread?

16. What are the chief means of preventing fire spread?

17. Why does a fire starting in a basement or lower floor frequently spread to the top floor before it does to intervening floors?

18. What is the minimum acceptable width of a fire exit?

19. What is the minimum number of exits required for safety?

20. Are outside fire escapes acceptable in new buildings?

CHAPTER XXIX

First Aid

The purpose of an organized accident-prevention program is to eliminate accidents (and exposures) that may result in injuries by removing the hazards, by protecting the individual worker, and by promoting safe practices. However, no program yet designed has succeeded in eliminating every injury. Therefore, even those establishments that have come nearest the goal of complete injury elimination have found it necessary and profitable to provide carefully for the treatment of those injured. This preparation involves both first-aid facilities and first-aid training. The dictates of humanity require at least reasonably effective provision for the succor of those injured, but it has also been found that employee participation through training in first aid can be strongly stimulative of safety-mindedness.

Early in the safety movement, many individuals charged with the prevention of accidents organized extensive and continuing first-aid training programs in the belief that by this means the whole safety purpose could be accomplished. Actually, nothing could be further from the truth. A safety program contemplates the elimination of injuries. A first-aid program contemplates the most adequate possible treatment of all the injuries that occur in spite of the effort to prevent them. Today it would seem that a careful appraisal of relative values is in order, for numerous accident-prevention engineers appear prone to neglect first-aid training and perhaps even adequate provisions for first-aid treatment because of failure to realize their value in accident prevention.

First-aid facilities

Adequate provisions for the first-aid treatment of all cases of injury or illness should be maintained in every establishment. The scope of such provisions will, of course, vary widely. Many large plants maintain facilities that approach those found in the modern hospital and offer extensive health-preservative services, particularly dental, eye testing and fitting, blood and urine analysis, and nutritional advice. However, the usual practice is to limit the plant facilities quite closely to first-aid needs and to

arrange for any other services needed through the usual professional practitioners.

The primary purpose of plant first-aid facilities is just what the term implies—to give prompt treatment to all who suffer injury at their work. Every other consideration is secondary to this. This purpose is twofold: to give prompt succor and relief in case of serious injury, and to prevent the infection of lesser injuries. Essential to the satisfactory functioning of first-aid service are:

1. Fully competent first-aid attendants.
2. Adequate quarters and equipment.
3. Proper organization and records.
4. Employee coöperation.

Competent personnel. The minimum fully satisfactory standard of competence is that represented by the full-time service of a trained nurse. In the very small plant, this is obviously impractical. The alternative is to select at least two responsible employees who, after having completed a standard course in first aid, would handle the first-aid work under the general supervision of a trained nurse or a doctor. These attendants should be allowed time to keep the first-aid room in order, check supplies and keep them up to date, and keep the needed records. They should be so chosen that one will surely be available during all operating hours. This is the minimum that is to be regarded as at all satisfactory. Anything less will in the long run almost certainly result in inadequate first aid, needless infections, needless suffering, and high injury cost.

Quarters and equipment. Every fixed establishment should have a first-aid room. It should be attractively finished, well lighted, kept spotlessly clean and orderly, and be situated near to toilet facilities. The minimum size for practical use is about 7 feet by 9 feet. Such a room will accommodate the following:

1. Hospital cot.
2. Stretcher—hung on wall brackets 6 feet above floor.
3. Writing table—to fold up to wall.
4. Stool.
5. Porcelain-top table.
6. Sterilizer—mounted on wall.
7. Medicine cabinet—4 feet 7 inches from floor.
8. Headrest chair with folding armrest.
9. Gooseneck lamp stand.
10. Corner lavatory.
11. Liquid-soap dispenser.
12. Sanitary can with cover.
13. File for medical records.

14. Floor lamp.
15. Telephone.
16. Treatment table or instrument cabinet.
17. Small office and surgical equipment, such as basins, pitcher, rubber gloves (sterile), scissors, tweezers, forceps, hot-water bottle, ice bag, etc.

The minimum first-aid supplies should be:

1. Tourniquet.
2. Pair scissors.
3. Teaspoon.
4. Medicine droppers.
5. Eye cup.
6. Assorted safety pins.
7. Paper drinking cups.
8. Roll absorbent cotton.
9. Small covered absorbent-cotton dispenser.
10. Package of applicators.
11. One package of sterile gauze.
12. Roll of 1-inch adhesive tape.
13. 1-, 2-, and 3-inch gauze bandage rolls.
14. Castor oil.
15. Some burn ointment.
16. Tincture of iodine or mercurochrome.
17. White-wine vinegar.
18. 4 per cent aqueous boric acid.
19. Aromatic spirits of ammonia.
20. Bicarbonate of soda.
21. White vaseline.

The nurse or doctor in charge will suggest additional supplies and equipment to meet the needs of the specific establishment. This person should have a good knowledge of the hazards of the plant. For instance, an inhalator should be promptly and unfailingly available if exposure to asphyxiant gases is likely. Special materials may be needed to prevent or to treat injury from chemicals, and so on. A foundry will require extra supplies for the treatment of burns, and so on.

Dependence upon a first-aid kit or kits is specifically not recommended except for small construction jobs, line crews, and other transient or short duration jobs. The record of the first-aid kit in fixed establishments is not satisfactory. Perhaps the chief reason for this is that the management that does not regard first aid of sufficient importance to justify the modest expenditure necessary to furnish the above-described minimum quarters and equipment will not give adequate attention to the maintenance of first-aid kits and to the first-aid service itself. Often two or more small establishments in the same building or in closely adjacent buildings may establish a joint first-aid room and first-aid services. For satisfactory results in such cases, whole-hearted coöperation is essential. This, once established, may happily lead to a coöperative safety setup. Many such setups are functioning effectively.

Organization and records. Unless definite procedure in case of injury is arranged for and thoroughly understood, injuries may be aggravated by bad handling or by unnecessary delay or both. Every supervisor should be fully instructed, preferably should take

a course in first aid. Many plants include key men from each crew in such a course.

The importance of getting adequate treatment for every minor injury should be fully understood by every foreman, and each should be painstaking in passing this knowledge on to his men and in getting them to report all small injuries. Even though foremen and men know in a general way of the danger of infection, satisfactory reporting for treatment is ordinarily not obtained unless the management stresses the need, gives definite instructions regarding the procedure, and keeps sufficiently in touch to see that the instructions are carried out.

Definite records should be kept. These should be as simple as possible, yet contain the essential information. The essentials are:

1. Requirements imposed by the terms of the applicable workmen's compensation act.
2. Data needed by the insurance carrier.
3. Information helpful to preventive effort.

For further detail, see the chapters, "Accident Records and Reports" and "Accident Investigation."

The management should keep as close a watch on the accident records as he does on any other important phase of production.

Employee coöperation. The problem of getting full employee understanding of the danger of infection and consequent unfailing reporting of all minor injuries for treatment is a troublesome one. It can be met adequately only by:

1. Insistent pressure by the management.
2. Continuous supervision, education, and instruction by the foremen.
3. A continuing informational campaign by the first-aid attendants.
4. The persistent use of available posters, literature, safety meetings, and other educational and stimulative means.

First-aid training

First-aid training has as its primary purpose the instruction of plant personnel so that when an accident occurs its severity may be controlled through proper handling of the injured employee. A well-developed training program has a secondary, and from the safety engineer's standpoint, perhaps a more important objective than simply the treatment of injuries. The very fact that employ-

ees are trained to be prepared for accidents reacts favorably on their interest in stopping accidents.

One of the basic requirements of every safety program is the maintaining of the active interest of each employee in his own safety, as well as in the safety of his fellow workers. Whenever this interest lags, the accident frequency rate rises. It has been demonstrated that a good first-aid training program has in many cases improved the safety consciousness of the group. The program provides for knowledge of different types of injuries, the effect of injuries on the individual, and the treatment required for each type of injury. In the discussions pertaining to these injuries, the tragic results that occur because of accidents are of course emphasized. The impression made on individuals in the class is excellent from the standpoint of safety psychology. It is this factor that has brought about marked changes in frequency rates immediately following intensive first-aid training. Records indicate that in some cases the improvement in frequency has been as great as 50 per cent during the months or year following such a program. These reports come from textile mills, steel mills, mines, and many other industries. The records also show that the rate of accidents among the employees who are being or who have been trained drops off sharply when compared to previous years, and that the frequency of accidents in this group is substantially below the frequency for the group of employees not taking such training.

A well-organized first-aid program will have as its by-products several factors that are of assistance to the safety man in maintaining his program. Experience shows that trained men give thought to their own welfare in terms of physically handicapped men. It is also indicated that individuals taking such a course begin to measure the cost of accidents, both in money and in physical suffering to themselves.

A first-aid program gives those who study it a much better understanding of the construction of the human body and its limitations; and of course such a program prevents added injury through improper handling of employees following an accident.

Under present conditions, first-aid training has been made available in virtually every community throughout the entire United States through the facilities of the American Red Cross. Even before the war, the Red Cross was doing an outstanding job through its field staff in training instructors and conducting first-aid schools. In 1939, over 300,000 certificates were awarded to people who had completed the Red Cross first-aid training. In addition to the Red Cross, the United States Bureau of Mines has

been active for many years in promoting and conducting first-aid courses in the mining industry. It has done much of this work in industrial areas also.

The war emergency caused a widespread upsurge of popular interest in first-aid training courses. The work has been greatly expanded and intensified. Undoubtedly, this will have a lasting value in a more widespread safety-mindedness. However, it is to be hoped that these courses will be continued with the return of peace. In normal times, a considerable sales job must be done to get workmen to take and follow through with what is necessarily a strenuous course of study.

Experience has shown that workers may become interested in the first-aid problem and subsequent training through several approaches. As in any effort to convince an individual that he should buy or sell or do a certain thing, appeal must be made to the benefits he will receive as the result of his action. The idea of possessing knowledge that enables one to act properly in an emergency, in the plant, on the street or highway, or in case of injury or danger to one's own family or loved ones, is an appeal that can be used to convince workers that they should for their own good take part in such a training program.

One consideration that must be given careful attention in introducing this type of training in a plant is the selection of an instructor. Much of the success of the program will depend on the knowledge of the instructor and on his ability to teach what he knows to those in the class. Both the Red Cross and the Bureau of Mines are ready at all times to assist in the furnishing or training of instructors for this work.

The question of the amount of training that should be given is also of prime importance. In some companies, it is a general policy to give a quite complete course in first aid to virtually all employees and to make this a continuing program from year to year. Other companies, feeling that this complete training is inadvisable for all employees, take instead a middle-of-the-road plan under which a limited group of employees in each department is given full training, and other employees are given fundamental training in the basic treatment of certain types of injuries. In this secondary training are included instructions for treatment of shock, instructions on how to locate the pressure points and on the application of tourniquets, and instructions in the prone-pressure method of artificial respiration. It would seem that this latter course is generally most advisable, particularly in large plants. The difficulty of maintaining classes for all employees is hardly warranted by the benefits that might result. On the

other hand, each employee should have a general knowledge of what to do and what not to do in case of injury.

In order to maintain interest in first aid and to keep small groups highly trained over a period of years, the development of first-aid teams has been an important feature of the safety and first-aid program in many plants, particularly in mining areas. These teams are trained to a high degree of skill, and in serious emergencies are able to function almost as well as a doctor or a nurse. The men on the teams are selected because of their ability to meet and handle emergency situations, and their instruction covers every possible angle of first aid following any type of injury. Interest is maintained for the team members through first-aid contests. Under prearranged conditions, teams are required to compete with teams of other plants or other departments, and to demonstrate their efficiency in the handling of problems that are presented to them at the time of the contest. Judges for these contests are furnished either through the American Red Cross or the Bureau of Mines.

The use of bulletin boards, small instruction cards, and bulletins from time to time to stimulate interest among an entire plant organization is advisable. Many plants post regularly on the bulletin board a chart showing the pressure points, as well as instructions on artificial resuscitation. These are simply means of maintaining interest in order to create a consciousness for safety. Motion pictures and film strips on such subjects as infection, first-aid methods, and so on, are available and will be furnished on request by the National Safety Council.

Resuscitation

The prone-pressure method of resuscitation for use with those who have ceased breathing due to electric shock, asphyxiation, drowning, or gas poisoning has received general acceptance. Unless or until mechanical breathing equipment in the hands of skilled personnel is available, this method should be applied. A recently developed variation, pole-top resuscitation, is being widely adopted in resuscitating men shocked to unconsciousness on poles. It saves the precious time required to lower an unconscious victim to the ground.

The following directions for resuscitation are standard:[1]

When the patient has ceased breathing due to electric shock, gas poisoning, or drowning, artificial respiration should be administered.

[1] From "Handbook of Industrial Safety Standards," published by National Conservation Bureau, New York City.

As soon as possible, feel with your fingers in the patient's mouth and throat and remove any foreign body (as tobacco or false teeth). If the mouth is tight shut, pay no more attention to it until later. Do not stop to loosen the patient's clothing, but immediately begin actual resuscitation. Every moment of delay is serious.

Lay the patient on his belly, one arm extended directly overhead, the other arm bent at elbow, and with the face turned outward and resting on hand or forearm, so that the nose and mouth are free for breathing. (See Figure 1.)

Kneel, straddling the patient's thighs, with your knees placed at such distance from the hipbones as will allow you to assume the position shown in Figure 1.

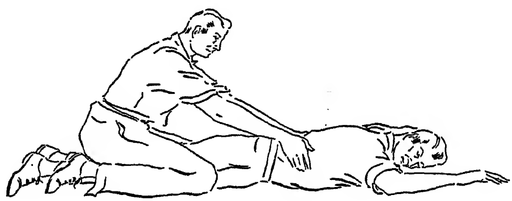


Fig. 1.

Place the palms of the hands on the small of the back with fingers resting on the ribs, the little finger just touching the lowest rib, with the thumb and finger in a natural position and the tips of the fingers just out of sight.

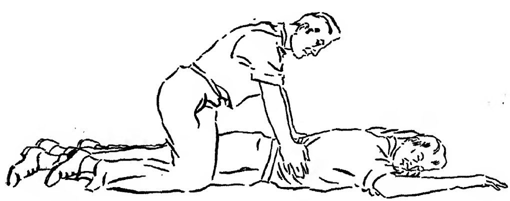


Fig. 2.

With arms held straight, swing forward slowly so that the weight of your body is gradually brought to bear upon the patient. The shoulder should be directly over the heel of the hand at the end of the forward swing. (See Figure 2.) Do not bend your elbows. This operation should take about two seconds.

Now immediately swing backward so as to remove completely the pressure. (See Figure 3.)

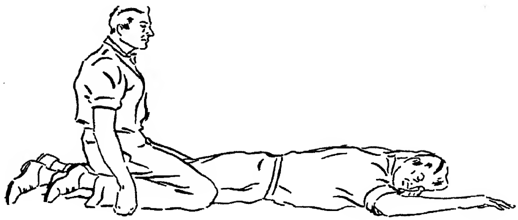


Fig. 3.

After two seconds, swing forward again. Thus repeat deliberately twelve to fifteen times a minute the double movement of compression and release, a complete respiration in four or five seconds.

Continue artificial respiration without interruption until natural breathing is restored, if necessary four hours or longer, or until a physician declares the patient dead.

As soon as this artificial respiration has been started and while it is being continued, an assistant should loosen any tight clothing about the patient's neck, chest, or waist. Keep the patient warm. Do not give any liquids whatever by mouth until the patient is fully conscious.

To avoid strain on the heart when the patient revives, he should be kept lying down and not allowed to stand or sit up. If the doctor has not arrived by the time the patient has revived, he should be given some stimulant, such as a teaspoonful of aromatic spirits of ammonia in a small glass of water, or a hot drink of coffee or tea. The patient should be kept warm.

Resuscitation should be carried on at the nearest possible point to where the patient received his injuries. He should not be moved from this point until he is breathing normally of his own volition, and then he should be moved only in a lying position. Should extreme weather or other conditions make it necessary to move the patient before he is breathing normally, resuscitation should be carried on during the time that he is being moved.

A brief return of natural respiration is not a certain indication that resuscitation should be stopped. Sometimes the patient, after a temporary recovery of respiration, stops breathing again. The patient must be watched, and if natural breathing stops, artificial respiration should be resumed at once.

In carrying out resuscitation, it may be necessary to change the operator. This change must be made without losing the rhythm of respiration. By this procedure, no confusion results at the time of change of operator and a regular rhythm is kept up.

Take care of the patient. An unconscious person becomes cold very rapidly, and chilling means a further strain on a vitality already weakened. Experience has shown that the cold to which the victims of gassing, electric shock, or drowning are often carelessly exposed is probably the most important cause of pneumonia, and this disease is the most dangerous after-effect of such accidents. As far as possible, keep the patient covered while artificial respiration is being given. Use hot pads, hot-water bottles, or hot bricks; but remember that an unconscious man has no way of telling you when he is being burned.

If it should be necessary to move the patient, keep him lying down and do not permit him to exert himself.

Never given an unconscious man anything to drink. It may choke him. Medical science knows no drug which of itself will start the breathing in a patient whose breathing has ceased.

Continue artificial respiration for at least four hours in all cases. Breathing has returned after eight hours in a case of electric shock, but in such instances the patient will give some evidence of recovery which will cause continued effort on the part of his rescuers.

Medical men have sometimes been mistaken in declaring patients dead, and employees of public utility companies have succeeded with resuscitation after such declarations. Therefore, the ordinary and general tests for death should not be accepted, and any doctor should make several very careful and final examinations and be sure specific evidence is present before pronouncing the patient dead.

REVIEW

1. What are the four essentials of a satisfactory first-aid service?
2. What is the minimum acceptable standard of competency for first-aid personnel?
3. Why should every establishment have a first-aid room?
4. What is necessary if good employee coöperation is to be had in getting all injuries properly treated?
5. What are the values of first-aid training for workmen?
6. How may workmen be interested in taking first-aid training?
7. Why is it so necessary to keep an unconscious person warm?
8. What is the basic idea of artificial resuscitation?

CHAPTER XXX

Personal Protective Equipment

While the soundest means of stopping any accident lies in the complete elimination of the hazard at the source, there are many sources where this cannot be accomplished. In such instances, the possibility of injury may be controlled in either one of two ways.

Under the first method, protective devices are located at the point of operation. These devices are of such a nature that they prevent the worker coming in contact with the hazard. Included in this category are such items as machine guards, flame baffles, belt shifters, nonslip shoes on ladders, and rubber protective equipment for electrical work. In cases where such protection cannot be readily provided, the worker may be guarded against the hazard through equipment or clothing which he wears during the period in which he is exposed. Such items as goggles, gas masks, asbestos clothing, rubber or leather gloves, and safety shoes fall within this classification.

It is important that the safety engineer have a complete knowledge of the types of protective clothing and equipment available and the suitability of each type for the hazards with which he must contend. The following discussion attempts to give that information in sufficient detail so that answers to each type of problem can be readily secured.

FACIAL PROTECTIVE EQUIPMENT

This classification does not include all safety appliances that are worn on the face, but only those that afford exterior protection. Masks are discussed in the respiratory protective section. The hazards of immediate concern include (a) impact from flying particles, (b) harmful radiant energy, and (c) chemical or metallic splash. Toxic or irritating gases, fumes, and dusts is truly a fourth hazard, but is listed separately to distinguish between the equipment groups involved; for air-borne contaminants are usually associated with injuries to the respiratory system.

All except (b) on the list are rather self-evident, but the danger of excessive radiant energy warrants further explanation. Within industry there are visible light sources that also emit radiations

that are invisible but injurious to the eyes. The ultraviolet rays are of short wave length and are found just below the visible region of spectrum; whereas the infrared rays are of long wave length and are beyond the opposite limit of the visible spectrum. Both are abundantly present in the welding flame and arc, and the latter also prevails in large quantities around almost all operations that produce intense heat. Those who work with molten metals, for instance, are subject to harm from infrared radiation.

Ultraviolet causes common sunburn, but it is often more severe in industry because the eyes, to perform the work at hand, must be directed at the source of emission. Even slight exposure may irritate the eyes painfully and cause temporary blindness. There is much conjecture as to the possible injury by infrared rays, but they are known to have penetrating power and may induce haziness of the cornea and lead to cataracts. Extremely bright visible rays are also detrimental, for they bring about eyestrain and fatigue.

Goggles, faceshields, and welding helmets are the products that are most important in the facial protective group.

Goggles

A significant number of goggle styles are available for safeguarding the eyes, but in the main, the dissimilarities among them are necessary to insure the best protection on all of the various operations or instances in which the possibility of harming the eye is a problem. The cup goggle and the spectacle offer the most fundamental basis for classification. The former is designed to offer protection in the most severe instances, while the latter is the result of a compromise with comfort and job efficiency and should be used only when the hazards are known to be of a lighter nature. When heavy impact, intense radiation, or dangerous chemical or metal splash is inherent with the task, the cup goggle is required. The pneumatic chipper operator, the acetylene burner or welder, and the person who constantly handles irritating liquids should wear the cup type. On the other hand, the operator of a small metal lathe is frequently adequately protected by the use of the spectacle.

As a means to brevity and clarity, the following outline is given to point out the most important functional variances in goggle construction.

A. Cup-type Goggles:

- I. Basic materials of cup construction:
  - (a) Metal.

- (b) Plastic:
  - 1. Thermo-setting type.
  - 2. Thermo-plastic type.
- (c) Leather.
- (d) Rubber.

II. Lenses:
- (a) Hardened (impact protective):
  - 1. Clear.
  - 2. Colored (filter).
- (b) Unhardened:
  - 1. Clear.
  - 2. Colored (filter):
    - (1) Welding lenses.
    - (2) Cobalt blue.
    - (3) Special-use filter glass.

III. Cup form:
- (a) Shallow cup.
- (b) Deep cup.

IV. Side shields of cup:
- (a) Solid.
- (b) Pierced with small holes.
- (c) Pierced with small holes and backed with solid bevel plate.
- (d) Provided with louvres.

B. Spectacle-type goggles:

I. Basic materials of frame construction:
- (a) Metals with noncorrosive finishes.
- (b) Thermo plastic materials.
- (c) Fiber.

II. Side protection:
- (a) With side shields:
  - 1. Wire screen.
  - 2. Clear plastics.
  - 3. Colored plastic.
  - 4. Leather.
- (b) Without side shields.

III. Lenses:
- (a) Clear and hardened.
- (b) Colored and hardened:
  - 1. Welding shades.
  - 2. Cobalt blue.

Metal and strong rigid plastics are used in the construction of cup goggles to gain high resistance to heavy impact. The latter is easily formed to facial contour and provides a surface that is more comfortable to the skin; hence, it is used most extensively. The thermo-setting type plastics, in general, are stronger than the thermo plastics and permit thinner cup construction. A goggle that is light weight without its strength being sacrificed can thus be offered. Such goggles are also more resistant to heat. Leather is used where the temperatures on the job are extremely high, although other types of cup goggles with insulated (bound) cup

edges are also employed for this purpose. The rubber cup is usually reserved for operations requiring exclusion of the outside atmosphere. The rubber gas-tight goggle is worn by handlers of finely divided harmful dusts, mine-rescue workers, and the like.

The functional form of the cup-type goggle is basically confined to two models: a shallow cup and a deep cup. The former is preferred, for, naturally, the nearer the lens opening is located with respect to the eye, the greater is the angle of vision permitted. The deep cup goggle is rightly used only as a means to afford coverage for corrective spectacles. However, it is well to note that hardened lenses can be ground to prescription and that all workers, whether or not they wear glasses, can be adequately fitted with the shallow cup style.

Cup goggles have a tendency to fog (condensation of moisture on the inside of the lens due to inequality of temperatures on the two surfaces) unless they are well ventilated. Where protection against impact alone is of concern, direct ventilation is made possible by piercing the sides of the cups and the lens, retaining rings with many small holes. However, when harmful radiation and dusts are encountered, these ventilating holes must be shielded so that they will permit passage of air but restrict the entrance of light and fine particles. Welding goggles are thus made with side shields that have louvres to permit indirect ventilation without allowing unfiltered light to penetrate into the cup. Passage of liquids is prevented by mounting a solid bevel plate a fraction of an inch behind the pierced side shield. In the case of the gas-tight rubber goggle, no ventilation can be allowed because the contaminants are air borne. The sides of the cups are solid, and fogging or moisting must be prevented by some other means. Some gas-tight goggles have a water retainer within the cup and, with a shake of the head, the wearer can clear the lenses by splashing water over the inside surface. This action breaks the surface tension of the condensation globules and they are taken up by the water. The refractive power is thus greatly reduced and visibility is restored. Antifogging agents are also available for goggles that, by the nature of the atmosphere in which they are used, cannot be well ventilated. The effectiveness of such agents depends upon ability to reduce the surface tension of water.

Within the spectacle group, metal frames have proved most popular because they are strong without being bulky. Plastic frames are making some headway and are particularly good to use in atmospheres that are corrosive to metals and on jobs where there is an explosion hazard. Plastic frame spectacles are usually made of nonsparking materials throughout. Some individuals

cannot wear metal frame spectacles because of a skin condition, and plastics solve this problem well in most cases. However, the plastic used in spectacle frames is inferior to steel in the way of heat resistance and strength, and these limitations should be remembered when selecting a spectacle for any particular type of work. The fiber frame is normally confined to hot inspection work that does not entail constant use of the goggle.

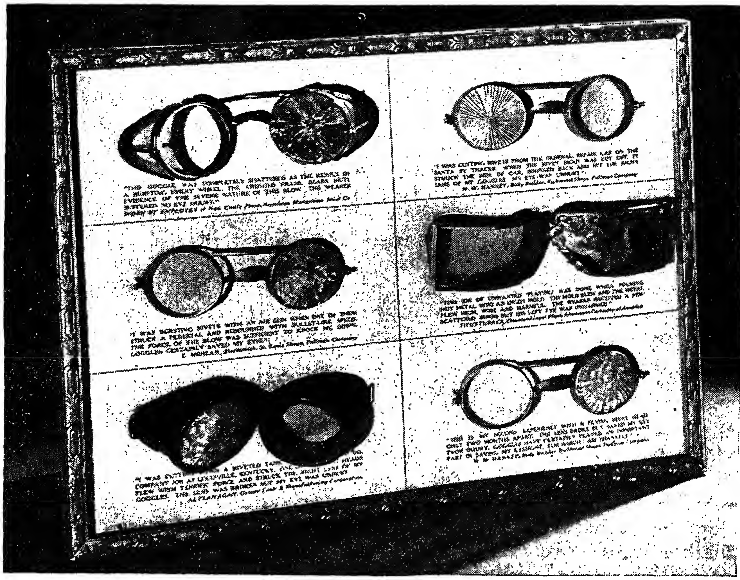
Spectacles without side shields are to be worn in cases of frontal exposure only. An operator of a small drill press is afforded good protection by spectacles without side shields if his machine is well isolated from other operations which could cause particles to fly within his work area from other directions.

Screen side shields provide the greatest impact resistance, but clear plastic shields allow better visibility and are generally thought to be strong enough to guard against side impact wherever the spectacle-type goggle can safely be used. For protection against limited radiation, leather or colored plastic shields that are of the best possible filtering quality should be mounted on spectacles with the proper colored lenses. The "flash-goggle," which is worn under a welding helmet or by those who work near welders, should have these shields to insure against harm from stray radiation.

The most widely used clear impact-protective lenses are of the "case-hardened" type (heat treated), and if properly constructed, they will withstand very hard blows. Dropping a ⅞-inch round steel ball on a lens that is supported in a cup, from a height of 50 inches, is considered a fair test. Green-colored (called welding or filter) lenses are available in many different shades for all degrees of hazard. In general, the lens is made darker and the visible light transmission is reduced as it becomes necessary to provide more complete protection against combined ultraviolet and infrared radiation. Careful choice of shade numbers is therefore required, for it is necessary to provide adequate protection and yet permit as much visibility as possible; except, of course, in the instance of bothersome visible radiation. Well-defined standards for filter lenses are set forth in Federal Specifications GGG-H-211[1] and GGG-G-511, and recommendations for usage are best supplied by the safety equipment manufacturers. Special filter lenses are used when it is desirable to gain physical effects or to filter certain bothersome color lines in the visible spectrum. Hence, cobalt blue lenses have been employed to enable the melter to judge his heat accurately, and didymium lenses are used by the glass blower to absorb the bothersome sodium color.

[1] Obtainable from the National Bureau of Standards, Washington, D. C.

Unhardened filter lenses from shades 3 through 7 are used in cup goggles, and hardened lenses from shades 1.5 to 3.0 are used in both spectacle and cup goggles. Complete face protection is usually required when shades darker than shade 7 are needed, and more complete side protection than is provided by spectacles is necessary when lenses darker than shade 3 must be used. Basically, the cup goggle is not adequate when the harmful radiations entail the use of a lens that is darker than shade 8, and the spectacle has reached its effective limit at shade 3.



Goggles that have saved eyes.*

Unhardened clear cover lenses are available for cup goggles and are mounted over the filter lenses to prevent damage from welding splash.

Plastic lenses are entering the field but to date have not been generally accepted, chiefly because they scratch too easily.

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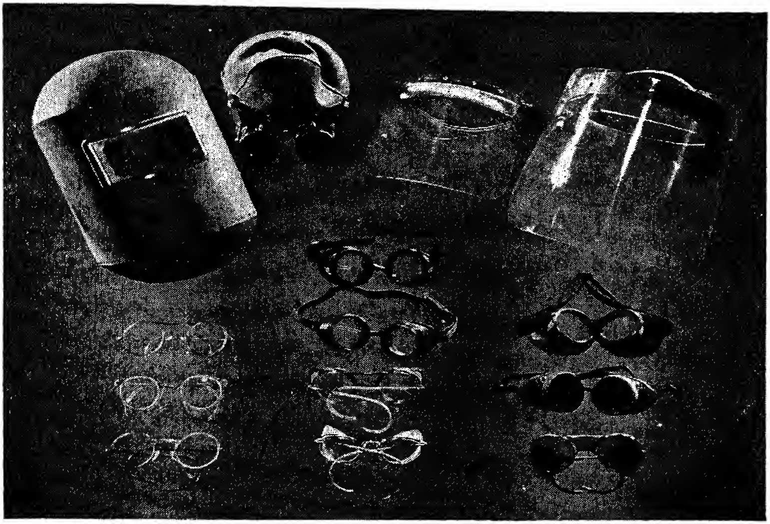
* This picture and the six immediately following are from the slide film *Right Dress* prepared by the National Safety Council and the Division of Labor Standards of the U. S. Department of Labor.

It is most important to choose lenses that have good optical qualities, and a set of accepted standards is provided by Federal Specifications GGG-G-501.

Other variables in goggle construction and design allow for personal fit, comfort, and attractiveness; but these are difficult to generalize.



Faceshields and goggles.*

Faceshields

A faceshield consists essentially of a headgear or band, to which a clear, plastic visor is attached by means of a friction joint so that the latter can be easily tilted upward and off the face. Cellulose acetate is the plastic most commonly used in the construction of the visor, and it is supplied in thicknesses between .020 inch and .060 inch. The rigid type headgear is generally conceded to be more durable than the elastic headband, and it is definitely more comfortable if it is designed in such a way that there will be no pressure points.

The faceshield is used for resisting limited chemical splash, dust, and light flying particles. Some colored cellulose acetates

* See footnote on page 366.

can be used to filter harmful quantities of ultraviolet, but care must be taken in the selection of the product. Metal screen visors also are available for attachment to faceshield headgears, and they offer excellent protection to the face against heat.

On jobs that require full face coverage, but which present an eye hazard that is too severe for the use of a faceshield alone, cup- or spectacle-type goggles should be worn under the faceshield.

Welding helmets

For welding operations that produce intense arcs and cause heavy metal splashes, welding helmets or shields that cover the entire face are necessary. Fiber is most often used as the basic material of construction because of its heat-resisting qualities. A curved top protects the front part of the head, while a curved bottom section shields the underpart of the chin. If the latter is not necessary, a straight-bottomed helmet will afford better ventilation. Chrome leather or fireproof duck bibs may be attached to the top of the helmet for back-of-the-head protection and/or to the bottom of the helmet for more complete neck and chest protection. When space is limited and the welder must do his work in cramped quarters, helmets formed entirely of chrome leather are most convenient.

Lens holders of metal or plastic materials are mounted in the front of the shield at eye level. A filter lens and a clear cover lens is placed in the holder, the latter to protect the welding plate from weld splash, for glass is quickly pitted by hot metal particles. Special coated cover lenses, which resist pitting over a long period of time, can be secured, and these greatly reduce the number of lens changes that are necessary when accumulation of metal on the cover plate restricts clear vision.

Holders with an extra hinged window, which holds the filter and cover lenses, are used to facilitate inspection of the weld and for other work that requires unobstructed vision and is done intermittently with welding. The darkened lens can be removed from the path of vision by manual movement of the hinged window, leaving a clear lens in the stationary part of the holder to guard the eyes against dust, impact, and so on.

In some instances, head protection is also a necessity for the welder; and this is particularly true where other workmen are performing their duties directly above his work area. A combination protective cap-welding shield assembly is recommended for the dual hazard. The unit is constructed in such a manner that the shield can be pivoted off the face without removing the cap, in much the same way as most standard rigid welding helmets can be pivoted on the fiber headgear. Provision for easy detachment

of the welding shield is usually made so that the cap can be worn separately when desired.

Adaptations of the welding helmet design are found in other special-purpose facial protective equipment. Helmets with a screen front are employed in cases of extreme impact and/or heat exposure and for profuse and heavy metal splashes such as are inherent with babbitting.

Conclusion

Facial protective equipment is one of the most widely required types of personal safety apparel, and the need for it is quite obvious. Even the mail boy, in his rounds through the factory, may be subject to face injury and should, in such case, wear goggles that will best guard him against the hazards encountered throughout his route.

In the selection of safety equipment for the face, careful consideration must be given to (a) degree of protection afforded, (b) job efficiency permitted, and (c) personal comfort allowed; too much protection for the job, with the worker overburdened by equipment, is no more effective than too little. It is manifestly unwise to issue a bulky wire screen mask to an employee when a light-weight spectacle would serve the purpose adequately.

PROTECTIVE CLOTHING

An important phase of modern industrial safety includes the protection of workmen with proper safety apparel. Mechanical and chemical processes give rise to hazards, such as dermatitis, burns, abrasions, punctures, and so on, and for adequate protection, clothing of asbestos, chrome leather, flame-proofed duck, rubber, neoprene, and the like, are worn.

No ironclad rules can be set up to guide one in selecting protective clothing for workers in the various industries. Four essentials, however, should be considered:

1. The garment must be reasonably comfortable in the temperature in which it is to be worn.
2. It must fit at least fairly well and not interfere with the worker's movements.
3. It must afford adequate protection against the hazard involved.
4. It must be durable.

The materials most commonly used in the manufacture of safety wearing apparel include:

1. Asbestos fabrics (flame-resistant):
   (a) Herringbone-weave cloth.
   (b) Basket-weave cloth.

2. Treated cotton fabrics (flame resistant).
3. Chrome leather (heat and flame resistant).
4. Wool fabrics (heat and flame resistant).
5. Rubber (acid resistant).
6. Neoprene (resists solvents).
7. Other synthetics (resist solvents and certain types resist solvents and acids).

Typical pieces of protective equipment.*

To have a complete understanding of the uses and applications of safety wearing apparel, it is recommended that a study of the advantages of the different materials available be made so that a proper choice of apparel for the operation or job, with its resultant hazards, be chosen.

The hands—fingers, thumbs, and palms—deserve first consideration. In operations involving the handling of hot or sharp-edged parts, gloves, mittens, or hand pads should be worn. To most people, gloves are just something to be worn on the hands; but in the industrial plant where hazard protection is required, gloves have to be more than just gloves—they must be the proper type to fit the protection problem involved. Experience proves

* See footnote on page 366.

that gloves, where properly selected for a particular job, do much to reduce cuts, scratches, blisters, burns, and so on. Mass production, or modern manufacturing methods, have made specialized hand protection designed for a particular hazard or group of hazards necessary.

Styles in protective apparel.*

Today, for the severest work in the foundries, steel mills, and so on, the necessary protection for hands can only be obtained with gloves or mittens that are reinforced with steel staples and that are steel sewed. The leather base for the steel-reinforced gloves is usually chrome tanned cowhide. This leather is ideal because it is flexible, tough, and of uniform weight. The steel staples are clinched into the leather over surfaces receiving the greatest wear, usually the entire palm, thumb, and, partially or entirely, the four fingers.

When flame and heat are a factor, aside from welding, where gloves made from chrome tanned cowhide, horsehide, or carpincho are used, gloves of asbestos only, or of asbestos combined with leather or wool, are used. Where heat is involved but wear is not severe, gloves made of asbestos only are suitable.

Where rough or sharp hot objects are handled, the asbestos gloves should be reinforced with chrome leather on the portions of greatest wear.

* See footnote on page 366.

Where extreme temperatures are encountered, the glove should have an insulating lining of cotton fleece or wool.

An entirely different problem arises when the protection required is not from the handling of rough or hot materials, but to protect against acids, alkalis, various types of oils, and solvents. Where acids only are encountered, rubber gloves usually will give protection, the weight, length, and style of glove to be used being decided by the type of acid and the amount of wear involved.

Gloves against heat, acids, abrasions, and electricity.*

Where a combination of oils and acids is encountered, gloves made of synthetics, such as neoprene, have been found to be satisfactory.

Where naphthas, oils, and solvents are encountered, rubber gloves should never be used, as rubber will disintegrate rapidly in contact with such materials. Gloves made of solvent-resistant synthetics are best.

Wrists and arms generally are protected by the glove gauntlet, shirt, or jacket sleeve. For some operations, however, gloves are not used, and the ordinary sleeve is too loose or does not afford sufficient protection. For jobs of this sort, sleeves or arm pro-

* See footnote on page 366.

tectors should be worn. The type of material of which they are made depends mainly on the degree of hazard involved.

For light splatters and sparks, sleeves of flame-proofed duck or of chrome leather will be found to be satisfactory. In handling sharp materials, such as glass, tin-plate, scrap, and so on, in addition to gloves, a leather arm protector reinforced with steel staples affords the best protection.

For the protection of feet and legs against metal splashes.*

Since the shoulders are taken care of generally by the clothing that covers the body, they seldom require special protection. In carrying sheet glass or other sharp-edged materials, however, the shoulders should be protected by pads of heavy felt covered with chrome leather or by some similar apparel.

Head hazards, aside from those requiring protective hats or welding helmets, usually fall into the classification requiring protection from heat, acid splashes, and so on. Asbestos hoods or wire screen masks provide needed protection against heat. Rubber hoods are provided where acid splash hazards exist.

Body protection is afforded by aprons, coats, jackets, and so on, of various types, depending upon the degree of hazard encountered.

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* See footnote on page 366.

Aprons of chrome leather are best suited for extra rough and sharp objects, such as glass, tin-plate, and castings. Where acids, alkalis, and the like are encountered, rubber suits or aprons are effective. Solvents and oils require clothing made of neoprene or one of the many other solvent-resistant synthetics.

Leg protection is available in various types of leggings, ranging from waist length to those that reach only part way to the knees. The type to be used will depend on the hazard involved. For

Footwear for protection and comfort.*

foot protection against sparks, spats are suitable; but these are not required where leggings are worn, as the flare of the legging affords this protection.

Where the hazard of foot injuries—from dropped objects, slipping, or acid spills—is encountered, proper footwear should be worn. Shoes incorporating steel safety toes or metal foot guards should be worn to protect against injuries to the feet from falling objects. Wooden-soled shoes are recommended where slipping hazards exist, and rubber boots or shoes should be provided to protect against acids.

* See footnote on page 366.

While the foregoing information can in no sense be considered a complete guide to all the numerous personal protective problems that are continually arising in the vast industries of our country, it does set up a procedure that should be of assistance in most cases.

Protective hats

Protective hats, for the worker exposed to head hazards, are worn as shields against falling or flying objects and the accidental blows and bumps of the job. In contrast to the "old felt hat" or cloth cap, which offers little or no protection against injury, the properly designed and constructed protective hat provides a rigid shell of strong material which resists fracture when struck and which tends to deflect the force of impact. A protective hat preferably is equipped with an inner cradle for the head, which, in combination with a flexible sweatband, suspends the shell on the head and effectively transmits the force of a blow over the entire head rather than localizing it in the immediate area where an object might strike.

Protective hats of molded laminated plastic are by far the most popular in industry and have many points of superiority over all other types. In the manufacture of these hats, layers of cotton textile material, impregnated with plastic, are molded into the desired hat or cap shape at high temperature and pressure. In the forming operation, the plastic combines with the fabric, making a very hard, smooth, impervious single material of exceedingly high strength, not subject to softening, swelling, or gaining in weight through exposure to heat or liquids. Aside from the inherent characteristics of the materials themselves, superior strength is incorporated into the crown of the hat through the use of a steel wire screen molded integral with the hat between the layers of cloth.

Protective hats, aside from absorbing force of any blow which the neck and back will withstand, are comfortable to wear and extremely durable. Protective hats are very comfortable to wear because they are light in weight, well balanced, and provided with soft, snug-fitting, replaceable sweatbands and adjustable, open hammocks of strong webbing in the crown. Adequate ventilation is provided by air spaces between the sweatband and the shell proper, keeping the head always comfortable and cool. Warm, snug-fitting, water-repellent, winter earlugs can be readily installed in the protective hat when inclement weather prevails. For men working in high places, protective hats are usually provided with a chin strap to prevent the hat from being blown off the head. Chin straps are usually made of a soft leather or web and are completely adjustable. Protective hats may be equipped with ventila-

tion holes without decreasing the protection afforded, provided these holes are placed in the proper position. Manufacturer's recommendations as to the location of the holes should be followed. Ventilation holes are employed only when extremely warm weather is encountered, as hats are comfortably cool under normal conditions.

In selecting the proper protective hat, it is important to follow certain recognized standards. The Procurement Division, United States Treasury Department, Specification No. 367-A is the basis upon which all branches of government purchase protective hats. This specification is also generally accepted throughout industry. Specification No. 367-A was set up by the United States Bureau of Standards and covers the minimum requirements for protective hats. The United States Navy has its own specifications on hats, although this is quite similar to the Treasury Department Specification No. 367-A. The United States Navy purchases its protective hats under Bureau of Ships AD Interim Specification 37-H-11 (Int.). Aside from specifications on the material and workmanship included in the aforementioned specifications, many tests are set forth which a protective hat must successfully meet in order to be approved for the purchase. The most rigid of these is the drop-ball test. In this test, the hats are first subjected to the action of an abrasive wheel. If the shell is coated, the coating is abraded until the basic material of the hat is exposed. The hat is then immersed in water for 48 hours and is immediately mounted on a wooden hat block in a position similar to that when on a man's head. A spherical weight is then dropped vertically onto the center of the crown. The hat in order to meet successfully the specification must withstand the impact without denting or breaking sufficiently to touch the wooden hat block or the inner side of the cradle or hammock.

Another test set forth in these specifications is the piercing test, which is conducted in somewhat the same manner as the drop-ball test except that a carpenter's plumb bob is dropped in such a manner that its point strikes the top of the crown squarely. Other rigid tests set forth in the specification are dielectric and inflammability tests.

The importance of these tests cannot be overemphasized. Protective hats that are not impervious to deterioration from exposure to weather, oils, water, common chemicals, perspiration, and so on, will soften and lose their shape after a few months wear, and will thus lose their protective qualities and require frequent replacement. The type of hat that meets government specifications lends itself readily to sterilization. New sweatbands and cradles can be readily installed in the hat.

Protective hats generally can be classified in two groups—the hat type and the cap type. The hat type, of course, affords the greater protection, as its rigid brim fully protects the face, neck, and ears, as well as the head. The cap type, however, has its place in industry; it is especially adapted for workers in confined spaces, as it affords greater freedom of motion. The general outdoor work hat is shaped like the famous World War I helmet with a full, broad, rigid brim which properly sheds water and protects against falling materials. This model is also available with an extra wide brim for use in chemical plants, extremely wet places, and so on. Designed with a full front and rear brim, but with a very narrow side brim, it is particularly adaptable for workers whose duties require carrying materials on their shoulders.

The cap type models can be divided into two groups: (a) those that afford the same protection as the hat type except that they have only a peak in the front and an ear-protecting and reinforcement bead on the sides and back; (b) the lighter-weight cap designed especially for the mining industry to protect mainly against the head-bumping hazards and from objects falling only short distances. Cap types are sometimes equipped with waterproof flexible brims to keep water and fine particles away from the back of the neck.

Aside from the standard industrial and mining protective hats and caps, firemen's hats, usually of a heavier construction, are available for use in fire-fighting operations. This is because the head hazards encountered in fire-fighting are usually greater than those in industry, and also because fireman's hats should provide additional dielectric protection. Crash helmets, formerly used only by sport enthusiasts, are now being used extensively by the armed forces, especially tank crews, test pilots, and so on.

Protective hats are being used extensively in the following industries: shipbuilding, construction, steel, petroleum, chemical, mining, quarrying, public utilities, lumber, and meat packing. The number of serious injuries or fatalities prevented by the wearing of protective hats is very great.

For example, a large steel company reports, "At two of our plants, it has been established definitely that 20 fatalities were prevented because of protective hats during 1941. These figures are not just estimates but they are definite records of falling materials striking workmen under such circumstances that, in each instance, it would have resulted in a fatality."

A national construction company working on a new ordnance plant recently attributed the saving of the life of a worker to the wearing of protective hats. One half of a fire brick fell from a

height of 61 feet and landed on the top of the crown of this worker's hat. This undoubtedly would have been a fatality if the company had not provided head protection for its workers.

A Midwest petroleum company reports that a driller who was wearing a protective hat was struck with such force by a large chunk of drilling mud, which had accumulated around the drill pipe, that his safety hat was jammed down on his head so tightly it had to be cut off. Had he not been wearing a safety hat, he would probably have been seriously injured. Not only are protective hats used extensively in drilling operations, but also around the refineries. A large oil company gives the following figures which portray the service protective hats are rendering on one property in reducing serious head injuries.

Year	*Protective Hats in Use*	*Severe Head Injury*	*Reported Cases Avoided*
First	36	7	0
Second	400	6	1
Third	700	3	8
Fourth	1226	2	7
Fifth	2493	1	10

With the increased tempo in the shipbuilding program since the outbreak of the war, protective hats have become vitally important in this industry. In some of the larger yards, protective hats have been accredited with the prevention of several serious injuries within one 24-hour work day, some of which would undoubtedly have proved fatal. One of the large shipbuilding companies report that in 1936, with an employment of only 5,000, they had 5 fatalities resulting from head injuries and averaged 14 brain concussions a month. Since 1936, when the hat program was instituted, they have not had a single fatality resulting from a head injury, and concussions are almost unknown. This result is even more impressive when one considers the increase in their personnel during the past several years.

A large northwestern lumber company reports that in a 20-day period 6 serious head injuries were averted by the use of protective hats. In one of the 6 cases, a limb weighing about 5 pounds dropped 70 feet, striking a power saw faller directly on the top of his head. Needless to say, this workman suffered dizziness for an hour or two from the force of the impact on the hat. However, he returned to work the following day with only a slight headache and no further symptoms. It is certain that this would have been a bad skull fracture and a possible fatal accident had not this workman been wearing his protective hat.

Aside from affording dielectric protection for electrical workers, protective hats have been responsible for the prevention of many

serious head injuries involving falling objects in this industry also. An employee of a large electrical company was working on some overhead lines when one end of a 2- inch by 12-inch plank, approximately 6 feet long, fell and struck him on the head. The shock of the blow stunned him for a second but did not cause him to lose his balance. Had not the protective hat absorbed the shock of the blow, the employee would have been knocked unconscious and fallen to the ground, a distance of approximately 60 feet.

One not associated with meat packing would hardly realize the importance of protective hats in this industry. A nationally known meat-packing firm reports that an employee working in the beef coolers accidentally railed a side of beef through an open switch. The trolley, falling not only with the force of gravity but also with the weight of the side of beef pulling it down, struck the worker on the head. Fortunately, this employee was wearing the safety hat which the company had provided for him. The trolley struck with such force that a small hole was knocked in the hat. The minor cut he received on the forehead did not disable him, and he was able to continue work without losing any time. Since hundreds of similar incidents have occurred in the meat-packing industry, a large percentage of the employees of meat-packing houses are enjoying the protection afforded by protective hats.

Protective hats were first used in the mining industry. Here their value has been proved over and over again, and at the present time, practically every man underground must wear a protective hat. Protective hats are also used extensively in open-pit mining and quarry operations. A typical experience reported by a mining executive states that one of his employees was drawing a post from under the draw slate and the post flew out and hit him on the head, rendering him unconscious for some time. It was the opinion of this mining executive and all those who investigated this accident that the only thing that saved this young man's life was the protective hat he was wearing.

The number of lives saved, together with the number of lost-time accidents prevented by the use of protective hats in industry, is conclusive evidence of their importance. The protective hat is rapidly becoming the "standard work hat" in industry.

RESPIRATORY PROTECTIVE EQUIPMENT

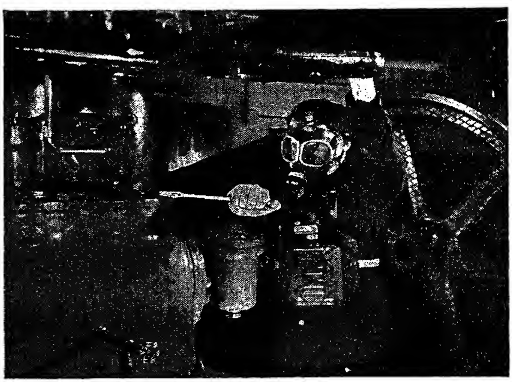
Why equipment is necessary

In order that the safety engineer may be able to determine when and what type masks and respirators should be worn, he

must understand why the protective device is necessary and how it functions. This requires that he have a general knowledge of those air contaminants which may cause injury if inhaled, as well

Courtesy National Safety Council.

Wearing a dust respirator while emptying a tumbling drum.



Courtesy National Safety Council.

Wearing a canister mask on a repair job.

as of how the various types of masks and respirators function to protect against these impurities.

The normal clean air on the earth's surface contains about 21 per cent oxygen, 78 per cent nitrogen, and small amounts of argon, carbon monoxide, and other materials. However, in

addition, almost all air as breathed by man contains some impurities or contaminants. Even country air contains small amounts of soil dust, weed pollen, and so on. The air in factories and mines unless specially conditioned and filtered usually has more impurities than has outdoor air. The amount and type of these impurities will depend upon the kind of processes, materials used, and amount of ventilation.

These contaminants suspended or mixed with the air are drawn into the body when the air is breathed. Some of the impurities, such as large dust particles, are trapped in the hair and mucus of the nose and throat, and part may pass out again with the exhaled air; but the greater portion enter the minute sacs in the lungs where they either remain or dissolve and pass into the blood stream. Some of these materials cause little or no injury to health; others are mostly irritating in effect; many will cause some form of disease or illness if they enter the body in sufficient amounts, while a few are deadly in minute quantities. For example, carbon dioxide is harmless (unless its presence results in a deficiency of oxygen), lime dust may irritate the lining of the nose and throat, silica dust will cause a lung disease known as silicosis if a sufficient quantity is inhaled, while a few breaths of air containing 0.1 per cent of arsine may cause death.

In considering whether a harmful concentration of impurities may be present in the working atmosphere, the safety engineer must also keep in mind whether there is a sufficient quantity of oxygen in the air to support life. There is normally 21 per cent oxygen in the air, but a man can get along on 17 per cent, although this will cause his breathing to be labored. At about 16 per cent a candle or oil flame will be extinguished, while at 13 per cent an acetylene flame goes out and most men cannot work. Below 13 per cent dizziness and headaches occur, and 8 to 10 per cent usually results in unconsciousness or death.

There is little danger of an oxygen deficiency low enough to cause ill effects in normal rooms or places of work. However, whenever it is necessary for persons to enter tanks, bins, vaults, or similar enclosed and poorly ventilated places, there is a good possibility that the oxygen content will be below normal. Many materials oxidize when exposed to the air and thereby absorb a certain amount of oxygen from the air. A tightly closed or sealed tank or bin which has contained oil, grain, or similar materials will probably be hazardous to enter, and even the rusting process on the inner walls of empty steel tanks after a period of time may have consumed so much of the oxygen that a person entering the tank would be overcome.

Since an oxygen deficient atmosphere gives no warning before overcoming its victim, it is an especially hazardous condition and persons should never be permitted to enter atmospheres suspected of oxygen deficiency without first testing the air or wearing the proper type of supplied-air mask.

General classes of air contaminants

Air contaminants are generally divided into two main groups: (a) particulate matter and (b) gaseous matter.

Particulate matter consists of finely divided particles of solids or liquids suspended or floating in the air, while gaseous matter includes those gases and vapors which may be in or mixed with the air. The distinction between particulate matter and gaseous matter is important when considering the type of respiratory protective equipment to be used, since a mechanical filter is needed to remove particulate matter, while chemical absorbents are necessary to clear the air of gaseous matter.

Particulate matter is further classified as dusts, fumes, or mists.

Dusts are mechanically generated particles usually resulting from such operations as drilling, blasting, crushing, and handling of rocks and minerals; sandblasting; stone and granite cutting; grinding and polishing. Industrial dusts vary in size from about ½ micron to 10 microns with the average being below 2 to 3 microns.[2] The smallest particle visible to the average eye is about 100 microns. Therefore, dust particles which remain in the air cannot be seen without magnification, although a beam of light, such as a sunbeam, may cause these particles to appear as visible because of the reflected light from the individual particles.

One reason for the small size of these air-carried dusts is that the larger particles settle out rapidly while the very small particles remain floating in the air for a considerable period of time. As an example, a dust particle one fourth of a micron in size will require approximately 10 hours to settle 1 foot, while a particle 5 microns in size will fall 2 feet in 5 minutes. This extremely slow settling rate of fine particles is the reason that fine dusts from a dusty operation, such as sweeping, may remain in the air for an entire working shift after the sweeping has been completed.

Fumes are particles produced in chemical and metallurgical processes and similar operations or by the decomposition of chemicals by heat and combustion. Most fumes have an average particle size of 0.2 to 0.3 microns, which is much less than the

[2] A micron is $\frac{1}{1000}$ of a millimeter, approximately 1/25,000 of an inch.

average size of mechanically generated dusts. The important harmful fumes are the fumes of such metals as lead, zinc, cadmium, or their compounds.

Mists are particles of liquids or mixtures of liquids and solids; in other words, wet particles. Good examples of mists are the fogs produced in spray-coating with siliceous glazes or paints that contain lead; also chromic acid mists produced during chromium plating.

Dusts may be classified into three groups according to their effect on the health of the individual breathing them. These groups are: (a) fibrosis-producing dusts; (b) nuisance dusts; (c) toxic dusts.

A fibrosis-producing dust is one that causes a disease or action in the lungs resulting in normal lung tissue being replaced with fibrous (scar) tissue. The most common dust under this group is silica, which causes the well-known disease "silicosis." Dusts under this group are not poisonous in that they do not affect any part of the body other than the lungs. In this type of dust, the finer dust particles penetrate more deeply into the lungs; and it has been definitely established that the small particles, 3 microns and less, are more injurious than are the larger ones.

For this reason, the degree of hazard of an atmosphere containing fibrosis-producing dusts is measured in terms of the number of particles and the particle size rather than the actual weight of the dusts in a unit volume of air. Lung diseases caused by fibrosis-producing dusts usually require several years to develop into disability; but once disablement occurs, there is no known cure and the disease may even continue to progress after the worker is removed from the exposure.

Lung diseases from fibrosis-producing dusts are common among such groups as foundry workers, anthracite coal miners, sandblasters, and granite quarry workers. The much publicized occurrence at Gauley Bridge, West Virginia, a few years ago in which several hundred workers driving a tunnel through a mountain of silica rock were reported to have been disabled from silicosis within a few months is an example of the possible effects of breathing high concentrations of these dusts.

A toxic dust is a dust of a poisonous material such as lead, arsenic, and so on, which produces injury to the organs of the circulatory system, heart, liver, kidneys, brain, or nervous system. When a poisonous dust is inhaled and deposited in the lungs, it dissolves and is carried by the blood to all organs and tissues. These dusts may also be deposited in the mouth and throat by inhalation or contamination with dirty hands and later swallowed,

so that poisoning may occur in this manner as well as through inhalation. The degree of the fineness of the dusts is not as important in toxic dusts as in fibrosis-producing dusts, and the air concentration is usually evaluated in terms of weight of the material rather than the number of particles.

Workers in smelters, lead storage battery plants and repair shops, paint pigment and glaze plants, and so on, are frequently exposed to these toxic dusts.

A nuisance dust is one that does not produce any known toxic effect or cause fibrosis tissue in the lungs. Such dusts, however, are discomforting to the worker and are often associated with increased respiratory diseases such as colds, bronchitis, and pneumonia. Flour, cement, aluminum, and coal dusts are usually included in this group.

The principal factors that determine the health hazard of dust in air are: chemical composition of dusts, the amount of dust in the air, size of a dust particle, and length of time of exposure. For example, the dusts generated in such operations as rock drilling, sandblasting, chipping, and grinding usually contain free silica, but this is frequently mixed with other dusts which may be either of a poisonous or a nusiance type. Therefore, in order to determine the dust hazards in such an operation, some knowledge of the percentage of free silica in the dust is desirable. The length of exposure is also important, since it largely determines the total amount of harmful dusts inhaled in the lungs over a period of time. Of course, like all diseases, some individuals become affected after much less exposure than do others.

Those contaminants classified as gaseous matter include foreign gases or vapors which may be mixed with the air.

The term "gases" is used to represent substances which exist wholly as gases in their best-known free state at ordinary temperatures and pressures. Examples are carbon monoxide, chlorine, and sulphur dioxide.

A vapor is the gaseous form of a material that is commonly thought of as a solid or liquid. Open tanks of such liquids as gasoline, carbon tetrachloride, and mercury give off considerable quantities of vapors. Many solids such as moth balls, mercury compounds, and insecticide powders also give off appreciable amounts of vapor, even at room temperatures. Such metals as lead and zinc will give off vapors when in a molten state, although the vapors from these metals usually oxidize to fumes (small particles) after a short contact with the air.

A knowledge of the fact that some liquids and solids give off toxic vapors is of importance to the safety engineer when he con-

siders the proper type of respirator or mask, since equipment that provides efficient protection against dusts, fumes, and mists usually do not protect against gases and vapors.

For example, the process of spraying paint is quite common in industrial plants and shops. Some paints consist of lead pigment, turpentine, and linseed oil. In spraying these paints, mists but no harmful vapors are produced. Therefore, a filter-type respirator, if correctly designed, can provide safe protection to the painter. However, many paints contain chiefly nontoxic pigments but have a liquid vehicle or thinner such as amyl acetate (banana oil), petroleum naphtha, or benzine which readily vaporizes upon being sprayed so that the working atmosphere is filled with vapors that are injurious if breathed. Here only an air-supplied or chemical cartridge type respirator can provide the proper protection.

The dusts of most minerals and metals do not present possible vapor hazards at ordinary room temperatures; but some other chemical compounds used in today's processes do, and, although apparently in the form of a dust, should be regarded, until this point is checked, as possibly releasing harmful amounts of vapors.

In deciding on the proper respiratory protection against gases in very high concentrations, consideration must also be given to the irritating effects of certain gases on the skin and eyes, and also on whether or not the gas can be absorbed through the skin.

Such gases as ammonia and chlorine irritate the eyes even in relatively low concentrations, so that a full facepiece or gas-tight goggles must be used. High concentrations of ammonia will also burn the skin, so that suitable clothing for protection of the skin may be necessary at times. Hydrogen cyanide can be absorbed through the skin in toxic amounts even when the mask itself keeps the gas from entering the respiratory tract.

Determination of the amount of contaminant in the air

It is not within the scope of this discussion to cover the various instruments and methods used in determining the quantities and types of air contaminants; a thorough treatment of this field would cover at least a book in itself. However, in order that a safety engineer or plant manager may tell how to go about such work if necessary, a brief discussion is given on this subject.

The amount and kind of many gases and vapors in air can be determined by collecting a sample of the air in a bottle and having a chemical analysis run on the sample. Instruments are available that will give direct dial or chart readings of the amount of some of the more common toxic gases such as carbon monoxide, benzol, and hydrogen sulphide. Instruments are also available that will

indicate the percentage and explosibility of combustible gases in the air, and this reading can sometimes be used as a rough check on the toxicity of the sample.

The determination of the degree of hazard of particulate matter in the air usually presents more difficulties than does determination of gases and vapors, since results must be obtained sometimes in terms of weight and other times in terms of the number of particles per cubic feet of air, and instruments which give a direct reading of the concentration of these materials are not available.

As explained previously, the degree of hazard of fibrosis-producing and nuisance dusts is usually referred to in terms of the number of particles in a given volume of air, while the degree of hazard of poisonous dusts and fumes is measured in terms of the weight of the toxic material per unit volume of air.

Where the number of particles must be determined, it is first necessary to obtain a representative sample of the material in a known volume of air and then count the number of particles in a small fraction of this sample, thereby making it possible to determine the total number of particles in the sample. Since most dusts are below 10 microns in size, a microscope having a magnification of at least 100 is necessary in order to see and count the particles in the sample.

The impinger is the accepted instrument employed in the United States for determining dust concentrations. A sample of the dust is collected in clean water or alcohol, transferred to a special dust-counting cell, and counted under a microscope. The period of sampling varies from 5 to 15 minutes, depending on the probable concentration and the operation or dust-producing cycle. Instruments are also available which collect a sample of the dust on a wet or sticky plate, in which case a microscope is also used to view the sample. Such devices collect a sample over a fraction of a second and provide only rough approximations of dust concentrations.

Toxic dusts and metal fumes are sometimes collected by bubbling the sample of the air through a suitable liquid; but a more common method is to collect the sample dry by the use of an electrostatic precipitator. In all cases, the sample must be analyzed chemically in order to determine the quantity and types of toxic materials present.

Where the size of the plant and type of operation is such as to make a great many determinations and studies on the air contaminants desirable, it is usually more economical and satisfactory to obtain the proper equipment and an industrial hygienist to make the studies. However, when determinations are needed

only infrequently, various organizations and laboratories are available which have equipment and personnel for such work.

Many of the insurance companies carrying industrial compensation insurance have facilities for such surveys, and also many of the states have industrial hygiene divisions in their departments of labor or health. A number of universities also are equipped to make determinations of samples submitted. The Industrial Hygiene Foundation, located in Pittsburgh, Pennsylvania, is a foundation supported by a large number of industrial and mining companies for the purpose of conducting scientific studies and investigations to find ways and means of preventing occupational diseases and promoting the health of workmen. This foundation has a well-equipped laboratory available to both members and nonmembers who need to make detailed studies of air conditions in plants.

As a preface to a general description of the various types of masks and respirators, a brief discussion of the United States Bureau of Mines' tests and approvals on this class of equipment is in order.

The United States Bureau of Mines is the official approving agency for respiratory protective equipment. Out of the extensive studies and tests in this field that it has carried on have come the standards necessary to determine the effectiveness and suitability of the various types of respiratory equipment.

Any manufacturer may submit a respirator or mask for approval. If the device meets all of the requirements, it is granted an approval certificate which bears an approval number and also specifically describes the device approved and conditions of use for which it is approved. The manufacturer is then required to show the Bureau of Mines Certificate Approval number on certain component parts of the device and also a copy of the complete certificate on each carton or package in which the device is marketed.

The Bureau has not established approval schedules on all types of respiratory protective devices, but approval schedules at present cover filter-type dust, fume, and mist respirators, canister gas masks, self-contained oxygen breathing apparatus, and self-rescuers.

The United States Bureau of Mines is the only organization or laboratory in the world that thoroughly tests respirators and masks for approval. For this reason, its approval is the standard of quality for these devices, not only in the United States, but also in certain foreign countries. The use of those masks and respirators approved by the Bureau for specific contaminants or conditions should be insisted on. Lists of approved devices and descriptive material may be obtained from the Bureau on request.

Types of respirators and masks

Personal respiratory protective devices are designed either to purify the inhaled air by removing the contaminants or to supply the wearer with clean air from a source entirely independent of the atmosphere in which he is working.

The equipment that purifies the air is designated as "air purifying," while equipment that supplies air from an outside or remote source is termed "air supplying." Air-purifying equipment can be subdivided into two classes: (a) those that make use of mechanical filters for removing particulate matter such as dusts, fumes, and mists, and (b) those that make use of chemical sorbents for removing gases and vapors from the air. The air-supplying types can be subdivided into (a) types in which fresh air is brought to the wearer from a distant point through a hose or pipe, and (b) self-contained oxygen equipment in which oxygen from a tank of compressed oxygen carried on the wearer is supplied for breathing.

Air-purifying types. The simplest and commonest mechanical filter device is the dust respirator. It usually consists of a filter of treated paper or felt, which screens or traps the fine particles of dust from the inhaled air. This filter is attached to a half-mask facepiece (one that covers only the nose and mouth) and is shaped to fit the contours of the face. The part of the facepiece that rests against the face must be made of some resilient material such as rubber so that comfortable and sealed contact is provided. Adjustable headbands are necessary for holding the respirator securely in position on the face. The better types of dust respirators are equipped with exhalation valves which open to permit the escape of exhaled air.

Mechanical filter respirators approved by the United States Bureau of Mines are available for various classes of dusts, fumes, and mists. The chief difference between various types of dust respirators is in the design of the filter. Some filters are efficient against all classes of particulate matter while others are effective against only one group or class. In general, a filter designed for a particular dust such as silica will provide longer service life than a filter that will provide the required protection against all classes of dusts, fumes, and mists. However, where a variety of these contaminants is present in the same operation or plant, the simplification obtained through the use of one respirator and filter approved for all classes of particulate matter may outweigh the longer life and lower resistance advantages of filters specifically designed for one type of dust.

The inhalation or check valves which close the entry ports between the filter and the facepiece during the exhalation breathing cycle are very desirable and greatly aid in the efficient performance of a filter-type respirator. Without these inhalation valves, a part of the exhaled air passes out through the filter in reverse and the contact of the warm, moist breath on the filter usually causes some condensation; as the paper or felt filter becomes wet, it readily clogs with dust and increases rapidly in breathing resistance.

Soft cotton facepiece coverings, commonly called "facelets," are available for most styles of filter respirators, and their use is recommended, especially around irritating dusts such as lime or where the individual's skin is sensitive to the rubber facepiece.

Increase in breathing resistance, rather than deterioration of the filter, determines when the filter in a respirator should be changed. Dust particles removed from the incoming air by the filter clog the filter pores and it becomes more efficient as a filter, but breathing resistance increases in proportion. When breathing resistance becomes uncomfortable, the filter should be changed.

Chemical cartridge respirators are similar in design to dust-, fume-, and mist-type respirators and usually employ a half-mask facepiece. However, in place of the filter there are single or twin cartridges containing a chemical, which remove certain gases and vapors from incoming air. These respirators are reasonably light in weight and have a low breathing resistance so that they can be worn continuously if necessary.

The chemical used in the respirator cartridges will vary with the type of gas or vapor from which protection is required. Most manufacturers supply one type of chemical fill for protection against organic vapors, such as benzol, carbon tetrachloride, and trichlor-ethylene, and another chemical fill for protection against acid gases such as chlorine, sulphur dioxide, and hydrogen sulphide. Special fills are sometimes available for protection against such gases as ammonia and metallic mercury vapors.

An important point to be borne in mind by the safety engineer in considering the use of chemical cartridge respirators is that they are not designed for emergency use or for use in atmospheres which may be harmful or toxic during a short period of exposure. These chemical cartridge respirators employ a relatively small quantity of chemical in order that they may be made light in weight, and the half-mask facepiece is not as secure as the full facepiece used on the regular gas mask. While the limiting concentration will vary with the particular gas and with the type and quantity of

chemical in the cartridge, it is generally considered unsafe to use chemical cartridge respirators in concentrations of acid gases higher than .05 per cent and in concentrations of organic vapors higher than .1 per cent.

Where chemical cartridge respirators are used against solvent vapors in paint-spray protection, the use of an auxiliary filter in front of the chemical cartridge to prevent the paint pigment from coating and clogging the chemical cartridge is desirable. Such filters should be inexpensive since they must be changed several times daily.

Canister gas masks. New processes, new gases, new combinations of gases used in industry today are continually enlarging the fields in which gaseous hazards are encountered by the worker. Higher pressures create conditions in which leaks are more difficult to guard against and often more serious when they do occur.

Canister gas masks are similar in application to chemical cartridge respirators, but they afford protection against relatively higher concentrations of gases and vapors for longer periods of time.

Canister-type gas masks consist of a facepiece, corrugated connecting tube, canister, and harness. The facepiece provides protection for the eyes as well as the face and respiratory organs. The canister contains chemicals for absorbing or neutralizing gases or vapors from which it is designed to protect. Canister masks may be divided into two classes: the industrial type with canister for protection against one gas or group of gases, and the all-service type which, as the name implies, is designed for protection against all industrial gases, smoke, and fumes.

One precaution in the use of canister masks must always be kept in mind—they may only be worn where there is sufficient oxygen to support life. They should never be worn in any confined space, such as tanks or tank cars, manholes, or any place that is poorly ventilated. The canister does not provide oxygen, it simply removes poisonous gases from the air that is breathed. The atmosphere may be tested with a flame safety lamp or a Wolf oxygen-deficiency indicator. If the flame is extinguished, an oxygen deficiency is indicated. Hose masks or oxygen-breathing apparatus should be used where an oxygen deficiency may exist.

Only masks bearing the United States Bureau of Mines approval, where approvals have been granted, should be used. To avoid confusion in use of an improper canister, the United States Bureau of Mines has established a schedule of distinguishing colors for canisters, which is adhered to by all manufacturers, in accordance with the following list:

Color of Canister	*Protection*
Black	Organic vapors
White	Acid gases
Yellow	Organic vapors and acid gases
Green	Ammonia
Brown	Organic vapors, acid gases and ammonia
Red	All industrial gases, smokes, and fumes

In a few industries, there has been sufficient demand for a canister for protection against a single gas to warrant its production and Bureau of Mines approval. Thus, two additional canisters are listed:

White with green stripe	Hydrocyanic acid gas
White with yellow stripe	Chlorine

Canisters are approved for use in not exceeding 2 per cent of most gases and in ammonia, 3 per cent. A question commonly asked is, "How long will the canister last, and when should it be replaced?" The service time will vary with the concentration of gas present, the rate of breathing, humidity, and the age of the canister. When the mask is in use, the canister will give complete protection for a period of time, and when it nears exhaustion, only a slight trace of gas will leak through. At the first detection of this leakage, the wearer should return to fresh air and replace the canister with a fresh one. When the canister is first placed in service, the bottom seal should be removed. At the end of one year, even though the mask has not actually been used, the canister should be replaced since it deteriorates slightly in normal air over a period of time.

Courtesy National Safety Council.

All-service canister gas mask.

All-service mask. The all-service gas mask will protect against all industrial gases, smokes, and fumes. The canister of this mask is red in color and is larger in size than the industrial canister. As before mentioned, the warning that a canister is nearing exhaustion is the penetration of a slight trace of gas. This is true of all gases except carbon monoxide, which is odorless and tasteless. All-service canisters are designed to give two hours protection against carbon monoxide. To provide a warning for carbon monoxide,

all-service masks are equipped with a timer which records the time that the canister has been used, whether continuously or intermittently, and which indicates by one complete revolution of its pointer that the canister should be changed. The all-service mask should be used for fire fighting and wherever carbon monoxide is suspected or known to be present. It is also recommended for use in departments or areas where more than one gas or varieties of gases may be present, otherwise it would be possible for the wrong mask to be used. If there is any doubt as to the gaseous hazard present or the proper mask to use, the representative of a reputable manufacturer of approved gas masks should be consulted.

Aside from the hazards of industrial processes, all-service masks should be provided in every industrial plant for those responsible for fire and plant protection. Contrary to the popular belief, a large percentage of the lives lost annually from fires succumb to gases, not to flames. It has been found that the gases from fires contain toxic constituents in sufficient amounts to make breathing dangerous or even fatal in a short time. Because this is true of the burning of common industrial materials, the need for adequate gas-mask protection for fire fighters is apparent.

It is important that those who are expected to wear gas masks be thoroughly trained in their use and limitations, so that they may be thoroughly familiar with the mask when it is required for use in emergency.

The following schedule for inspection and instruction is suggested:

1. Be sure the seal is removed from the bottom of the canister when the mask is placed in service.
2. Examine the mask parts, connections, and fittings for leakage and wear.
3. Instruct in the proper method of putting on and adjusting the facepiece. (Follow the manufacturer's instructions that come with each mask.)
4. Test the mask for gas tightness. When the mask is worn, place the hand over the bottom opening of the canister or close off the corrugated tube by collapsing it and inhale. If the mask is properly fitted and there are no leaks, the facepiece will collapse against the face.
5. Have the workman wear the mask for a 15- or 20-minute period to familiarize himself with its breathing resistance, and so on.
6. After using, clean and sterilize facepiece and replace in its case.

7. Keep a card record of the date of last inspection and length of time the mask has been used.

8. Replace the canister with a new one after it has been in service for one year, whether or not it has been used.

9. If the mask is properly designed and fitted, it may be worn for relatively long periods of time with reasonable comfort.

Courtesy National Safety Council.

A type of hose mask.

Supplied-air respirators. Supplied-air respirators, which bring clean air from a point outside of the working atmosphere, can be grouped into (a) air-line respirators for use in nonemergency operations and atmospheres not immediately harmful to life, and (b) hose-mask respirators for use in emergency and immediately toxic atmospheres.

Air-line respirators. The air-line respirator is so designated because the air supply is usually obtained from a regular shop compressed air line. These respirators are available either with half-mask or full-mask facepieces and consist essentially of a facepiece with adjustable headbands, a flexible or corrugated air-supply hose for connection between the control valve and facepiece, an air deflector which prevents the compressed air from

directly striking the face and eyes of the wearer, and a control valve by means of which the wearer can regulate the amount of air flowing into the mask.

Those air-line respirators specifically designed for use in sandblasting operations have a rubber or canvas hood attached which protects the blaster from flying sand or shot. This type is usually referred to as an abrasive mask or sandblast helmet.

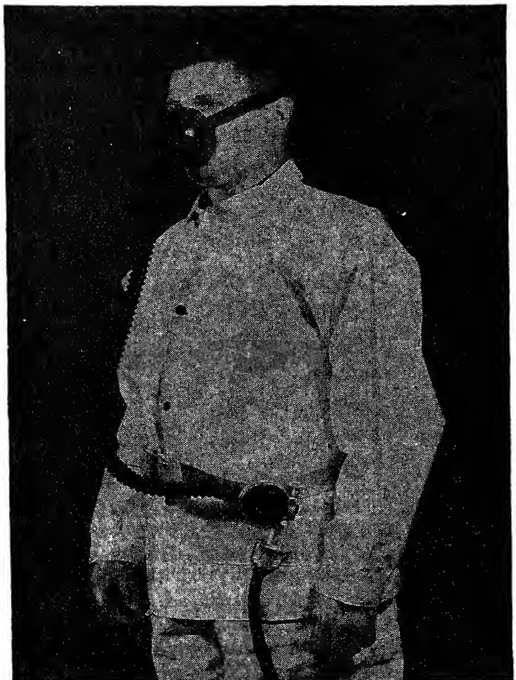
Extreme care should be exercised in obtaining a clean and safe air supply for air-line respirators; otherwise, the wearer may breathe a more injurious air than the air in which he is working.

Most shop air is compressed in the type of compressor in which pistons, similar to those on automobile engines, move back and forth in a cylinder. It is necessary to supply lubrication to the cylinder walls, and some of this lubricant is carried over by the compressed air. There is usually some rust and water condensation in the pipes or lines which convey the compressed air from the compressor to various points in the plant. Furthermore, unless care is exercised in the location of the intake to the air compressor, the air may be already contaminated before it is compressed.

For these reasons, ordinary shop air should not be fed directly to a mask or respirator without first being filtered by some air-line filter which is capable of removing most of the impurities from the air. However, there is one contaminant, namely, carbon monoxide, which may get into the shop compressed air under certain conditions; and this gas is not removed by the ordinary air filter. Since carbon monoxide, being odorless and tasteless, does not give warning, the worker will probably not be conscious of it until he is affected. The cases where carbon monoxide has contaminated compressed air have been caused either by the intake of the compressor being near the exhaust of an internal combustion engine, or by the compressor becoming overheated and igniting the lubricating oil in the compressor cylinders or that carried over into the air receiver. Care in locating the compressor inlet and in maintaining the compressor in good condition reduces possibility of carbon monoxide contamination.

It is also hazardous to supply compressed air directly to a mask or respirator, if the pressure exceeds 25 pounds per square inch, since the velocity of high-pressure air may drive some particle of rust or dirt into the face or eye of the wearer, or the high pressure may rupture the respirator air hose or some of the metal parts. It is considered a good safety practice to install a pressure reducer or regulator near the point where the air-line respirator is attached to the compressed air line; this regulator should be set to reduce the air pressure to the figure recommended by the manufacturer

of the air-line respirator, but in no case to a figure exceeding 25 pounds. As a further safety precaution against high pressure, should the regulator fail to function, the Bureau of Mines recommends that a relief or pop-off valve be installed preset to release at a pressure slightly above the setting of the pressure regulator.



Courtesy National Safety Council.

A type of supplied air mask.

Compressors or blowers are available which do not employ lubricating oil or any other material that will contaminate the air during compression. Such blowers usually operate at a pressure range of from 3 to 10 pounds per square inch; when these are used as a source of air supply, pressure reducers are not necessary. In some blowers, water is introduced into the compressor chambers to cool and wash the air. These devices are particularly satis-

factory where a separate or individual air source is to be installed for supplying respiratory devices.

Hose masks. The hose mask is a respiratory protective device in which clean air from an uncontaminated source is supplied through a hose to a mask assembly worn by the person to be protected. With the mask adjusted so as to be gas-tight, the fact that the wearer breathes air coming from the remote end of the hose makes its operation simple and easily understood. Hose masks fill an important place in the field of respiratory protection. Workmen like them because of their simplicity.

Courtesy National Safety Council.

Welder's outfit (left): fiber mask, chrome leather gloves, jacket, and chaps. At right: sandblaster's rubberized clothing.

Hose masks are used to furnish fresh air to the workman who must enter and work in highly concentrated gaseous or oxygen-deficient atmospheres within a short distance from fresh air—in places such as tank cars, oil storage tanks, sewers, and the like. Units are available for supplying as many as four men. Fresh air is taken from the outside and drawn or blown through the hose attached to the mask facepiece. The wearer is restricted in his travels to the length of the hose, which may, however, be as long as 150 feet.

Hose masks consist of a full gas-mask facepiece with corrugated tube connected to varying lengths of 1-inch-diameter hose, anchored to a body harness and usually a blower. They differ from air-line respirators in that they operate independent of any

source of compressed air and that, even when used with a blower, it is possible to breathe in the event of blower stoppage. Thus, they are safe equipment to use in atmospheres immediately dangerous to life.

Hose masks possess many advantages where the extent of the space to be entered is definite and limited. They fully protect the respiratory system against gases, vapors, dusts, and mists. Since they do not depend on chemicals or compressed oxygen, they may be used over extended periods with low-maintenance costs.

Hose masks, however, have some limitations. The wearer is definitely limited by the length of the hose, which must not be in lengths too great for safety. He must emerge from the space entered the same way as he went in. He must also take care to keep the extension hose from becoming caught or fouled.

In selecting a hose mask for a specific job, the following conditions should be considered:

1. Blowers should be used on all outfits using more than 25 feet of hose. They assure coolness, comfort, effortless breathing, and maintain sufficient positive pressure inside to insure an ample flow of air to the wearer.

2. Hose should be suitable to resist action of any outside substance. For instance, in petroleum work oilproof hose should be specified. Lengths selected should allow sufficient clearance at the blower end to insure fresh air.

3. Wherever possible, approved hose masks should be selected. Approval of the mask by the United States Bureau of Mines (the official government agency for approving respiratory protective devices) protects and assures the buyer that he has invested in a device that conforms to the best accepted standards, and gives him a status both from the practical and legal standpoints.

Hand-operated blower hose masks are furnished with double outlet blowers so that two men can work on one assembly or, if it is only necessary for one man to do the work, the second mask assembly can be available for use in any emergency that may arise. This type of mask is limited to use with not more than 150 feet of hose on each blower outlet (150 feet is the limit for which Bureau of Mines approval is granted). All hose masks operate on the principle that the blower end be kept in clean uncontaminated air at all times.

Motor-driven hose masks use the same facepieces, safety belt harness, hose, and blowers as the hand-operated type and are generally arranged so that they can be operated by hand if electric

current is interrupted, or where electricity is not available. Motor-driven assemblies are available with four outlets on one blower, and any number of the outlets can be blanked off if not required.

While motor-driven hose masks are made up essentially of parts used on approved hand-operated masks, none of the motor-driven type are approved by the United States Bureau of Mines, since they do not (as of 1943) have a schedule to cover motor-driven assemblies.

Hose masks are available with 25 feet of hose (without blower), where this length of hose is adequate to reach fresh air. Masks without blowers are not recommended by the Bureau for use with more than 25 feet of hose.

Training in the use of hose masks should consist of the following:

1. See that gaskets are in place on all union connections.

2. Connect lengths of hose and attach to blower outlet if blower is used. When only one hoseline is being used, close off the unused blower outlets with caps provided for that purpose.

3. Attach free end of hose to harness.

4. Connect corrugated breathing tubes to hose and to facepiece.

5. Adjust length of shoulder straps so that body strap falls in proper position around the waist. Adjust the body belt for a snug, comfortable fit.

6. Follow the manufacturer's instructions for putting on and adjusting facepiece.

7. Test facepiece for leakage by closing off the corrugated tube or tubes, and inhale. Collapse of the facepiece and lack of inward leakage are indications of a tight fit. Investigate and correct any leak detected.

8. *a*. On blower-type masks *be sure the blower is placed in clean fresh air*. Have the man wearing the mask indicate to blower operator when he is receiving the desired amount of air, and operator can continue to crank or operate blower at this same rate.

b. On masks without blower, *see that end of hose is anchored securely in clean fresh air by means of the spike or hook*.

9. Have mask worn in fresh air for fifteen minutes so that wearer becomes familiar with its operation and gains confidence in the protection which it provides.

10. After use, clean and sterilize facepiece, clean hose if necessary, and see that mask is properly replaced in the trunk provided.

11. Store mask in a cool dry place where it will be readily and conveniently available when needed.

Note: The same procedure recommended for training should be followed in actual use, except, at the end of Step 8, proceed with work required. Steps 10 and 11 should be followed after the work has been completed.

Oxygen-breathing apparatus. The purpose of oxygen-breathing apparatus is to provide respiratory protection for persons engaged in fire fighting, rescue, or repair work, in atmospheres containing concentrations of gases too high for safe use of canister-type masks, or where the oxygen content is below the minimum necessary to support life. The apparatus consists essentially of a steel cylinder containing a supply of oxygen under high pressure, valves to control the pressure and circulation of oxygen, a cooler and rubber breathing bag which function as a low-pressure oxygen reservoir, breathing tubes and mouthpiece, and a regenerator for purifying the expired breath and removing carbon dioxide from it.

Unlike the hose mask, where the wearer is limited by the length of the hose reaching to fresh air and must return by the same route by which he entered, the oxygen-breathing apparatus is completely self-contained. The wearer carries his own supply of oxygen with him, does not breathe to or from the surrounding atmosphere, and may pursue his work for a full one- or two-hour period, according to which of two available types he is wearing.

The one-hour apparatus is available in two types—one worn on the chest, the other on the back. The chest type is the most popular. The two-hour type is available only for wearing on the back. Each type is Bureau of Mines approved when equipped with mouthpiece. The apparatus is designed to provide protection for the rated period of time with the wearer working under maximum exertion.

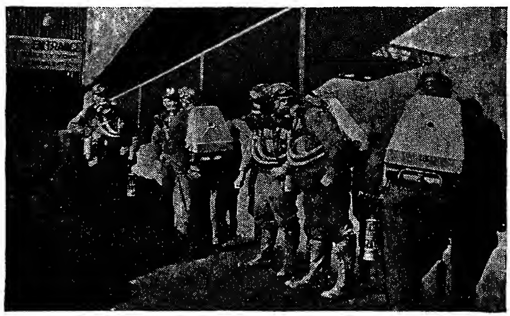
The steel oxygen cylinder is charged to a pressure of 135 atmospheres (1,985 pounds per square inch). It is fitted with a valve which allows the passage of high-pressure oxygen to a reducing valve where the pressure is reduced to approximately 5 pounds per square inch. Thence the oxygen flows through a tube in the cooler to the seat of the admission valve.

The admission valve is so designed that a bumper on the breathing bag opens it when the bag is deflated and closes it when the bag is inflated. Oxygen is thus admitted jointly to the breathing bag and cooler, whence it is drawn through a breathing tube to the mouthpiece (or facepiece). When the apparatus is equipped with a rubber mouthpiece, there is a spring clip for closing the nostrils.

The mouthpiece and facepiece are both equipped with inhalation and exhalation valves so that the flow of oxygen must con-

tinue in the one direction. The mouthpiece is equipped with a combination saliva trap and release valve which permits discharge of saliva accumulations to the outside without any external air being drawn into the apparatus.

Exhaled air passes through a second breathing tube to the regenerator, which is filled with a granular chemical that removes the carbon dioxide. The exhaled air contains from 3.6 to 6.6 per cent carbon dioxide. The balance of the exhaled air unites with oxygen coming from the breathing bag and is again rebreathed. A pressure gauge indicates continuously the amount of oxygen remaining in the cylinder.



Courtesy National Safety Council.

Mine rescue crew with oxygen helmets.

A bypass tube extends from the cylinder valve direct to the cooler, through which oxygen may be admitted, independent of other working parts.

A safety valve is installed in the low-pressure system and set to release when the pressure exceeds 7 pounds, producing a whistling sound.

No one should ever wear an oxygen-breathing apparatus without first having received thorough training in its use and servicing. The manufacturer will coöperate in this instruction, and courses leading to a certificate are offered by the United States Bureau of Mines.

There is an ever-increasing need for oxygen-breathing apparatus in the industrial field. Fire departments, public utilities, steel mills, chemical plants, refineries, steamships, and the like, all find the oxygen-breathing apparatus indispensable in emergency rescue work and for emergency repairs. It is used extensively in

underground passageways, basement fires, storage tanks, and so on, where there is little or no means for natural ventilation.

Care and maintenance

When the safety engineer has selected the most suitable type of mask or respirator for a particular hazard or type of operation, the most important part of his job is yet to be done—that of seeing that the devices are properly worn and that they are maintained in efficient condition.

At first, there is usually a reluctance on the part of persons to wear masks or respirators. This can be overcome by carefully explaining to each worker the hazards involved and the necessity for wearing the equipment to protect his own health. Next, he should be taught to wear the equipment correctly and should learn the function of its various component parts.

The degree of training necessary for a particular mask or respirator will depend on the intelligence and experience of the wearer and also on the particular type of device. Filter and cartridge-type respirators are relatively simple, and only a few minutes' instruction may be necessary to demonstrate their fitting and use. The canister-type mask and the hose mask require more instruction and training, since these devices are usually worn in emergency conditions. The self-contained oxygen-breathing apparatus should only be worn by persons who have undergone thorough training in its use.

Failure to keep masks and respirators clean and in efficient operating condition is common in many industrial plants where such equipment is used. This neglect is responsible for much of the resistance of workers to wearing the equipment and thus for its failure to provide the protection intended. Neglect also makes it necessary to replace the equipment more frequently.

Respiratory protective equipment that is used chiefly for emergencies should be inspected carefully after each use in order to determine whether any of the parts have become damaged or the canisters exhausted. Furthermore, a definite system should be established for inspection at regular intervals.

The equipment should be stored in a clean, dry place where it will not be tampered with and will be conveniently available when an emergency arises. Definite responsibility for periodic inspection and checking after use should be given to one person, and a record should be kept of the date of each inspection and the condition of the equipment.

Such respiratory protective devices as respirators and abrasive blasting masks which are worn frequently or continuously in pro-

duction or maintenance operations require special arrangements for regular cleaning inspection and repair. This should be the responsibility of one specially trained employee.

The following rules for care of respirators have been found to be practical and to produce the desired results.

1. Always give the same respirator or respirators to the same men.
2. Have a definite place to leave dirty respirators and pick up clean ones.
3. Establish a maximum length of time the respirator may be used before it must be serviced and cleaned, and keep a record of the dates inspected.
4. Establish a simple, effective method of sterilization at regular intervals.

The respirator can always be returned to the same man if it is numbered with his check number. If the respirator has a fair-sized metal part, numbering can be done with a steel stamp or an electric marking pencil. Respirators using plastic parts can be identified readily if the worker's name or number is typed on a piece of paper and cemented to the plastic with plastic cement. Since this cement is usually transparent, a coating can be applied over the label; and after the cement is dry, the label will not be affected by water or other material.

The most suitable method for cleaning and sterilizing special protective equipment is somewhat dependent upon the materials used in its construction. However, almost all metal rubber and plastic parts will stand scrubbing with soap and lukewarm water. This method is most effective in removing dust, dirt, oil, grease, and perspiration. After the parts are cleaned, they should be rinsed in water and sterilized.

The factors to be considered in selecting a suitable sterilizing agent are the effect of the agent on the materials and parts to be sterilized, the effectiveness of the sterilizing agent in killing common bacteria, the effect of the agent as a skin irritant if small amounts remain upon parts which contact the skin, whether or not the sterilizing agent will leave an objectionable odor for some time after it is applied to the equipment, and its convenience to use, its cost, and its availability.

REVIEW

1. What should always be done (as far as possible) before resorting (except as a temporary measure) to the use of protective equipment?

2. Should an electric welder wear eye protection under his welding helmet?

3. What are cup-type goggles?

4. What measures should be taken to get men to wear eye protection?

5. What four essentials are listed for safety clothing?

6. What is meant by "protective hat"?

7. Have protective hats proved to be of much value in preventing injury? On what types of work?

8. What two types of respiratory protective equipment are effective in an oxygen-deficient atmosphere?

9. How do dust respirators work?

10. What respirator should be used in an atmosphere containing 5 per cent of CO? In one containing 5 per cent of ammonia?

11. What are the limitations of the hose-line respirator?

12. Why is air from the ordinary plant compressed air system unsafe to use in a supplied air respirator?

13. What is meant by a nuisance dust? A toxic dust?

14. What standard of quality should always be insisted on in respiratory equipment?

15. What is meant by the term, "air purifying respirator"?

16. What is a canister gas mask?

17. Who should use oxygen-breathing apparatus?

CHAPTER XXXI

Industrial Health Hazards

In order to obtain practical results in the control of industrial health hazards, we need the combined efforts of the physician, the engineer, the chemist, and the nurse. Basically, we can divide our mode of attack on industrial health hazards into two parts: first, we must attack those problems concerned with the hygiene of the individual, and second, those dealing with the environment in which the individual works and lives. The first function comes within the scope of the medical sciences. The second function deals with engineering practices and forms the basis for this discussion.

Under medical sciences would come the allied professions—nursing and the various medical specialties, such as pathology and physiology. Engineering services would include, in addition to engineering, the work of other public health personnel, such as chemists, bacteriologists, and biometricians. In other words, the functions coming within the province of the medical department are concerned with the individual, while the functions with which the engineer must concern himself deal with the environment.

In so far as the *working environment* is concerned, it is a function of the medical department to determine the existence of such diseases as may be due to this working environment. On the basis of the physician's findings, the engineer is in a position to learn what unhealthful conditions should be investigated and where control measures need to be initiated. It is essential, therefore, that the various professions clearly understand the functions of each and approach the solution of the industrial hygiene problem as co-workers in a joint effort, coöperating with one another to the fullest extent.

Ill health and premature death have been associated with the nature of man's livelihood from time immemorial. Studies in recent years have indicated clearly that the health of workers engaged in industry can be affected by the conditions, materials,

and processes of work. For these reasons, important functions in industrial hygiene are the study of the workroom environment and its effect on health, and the subsequent development of methods for the control of environmental hazards.

Under ordinary peacetime conditions, the industrial worker spends less than one third of his time at his place of employment; and even under the unusual stresses of war production, we know that any appreciable sustained increase in this ratio of working time to rest and recreation time will not increase and may decrease total production. Thus, it is evident that the home and community environments have an influence on the worker's health and also bear an important relationship to the so-called nonoccupational diseases that are a major cause of time lost from work. For this reason, attention must also be given to factors outside the workroom which have a bearing on the worker's health and efficiency (1)[1]; but this discussion will be limited to consideration of the working environment only.

However, prior to discussing the various problems in industry, it may be well to define the present conception of industrial health hazards.

Classification of health hazards

While there are several classifications of health hazards in industry, one version is to divide them into three types: chemical, biological, and physical.

Under *chemical hazards,* we have the important group of poisons, of which there are a great number and variety. Dublin and Vane (2) list some 128 groups of industrial poisons in the United States, associated with approximately 1,500 occupational exposures, exclusive of substances that may cause dermatoses. These chemical elements and compounds may occur in the solid, liquid, or gaseous state. Whenever materials undergo changes in physical or chemical state or in physical size, some of the material, in the form of dusts, fumes, mists, gases, or vapors, will escape into the air of the workroom unless proper control measures are applied to prevent this atmospheric contamination. Industrial hygienists differentiate these contaminants as follows (3):

Dusts: Solid particles generated by handling, crushing, grinding, rapid impact, detonation and decrepitation of organic or inorganic materials such as rock, ore, metal, coal, wood, grain, etc. Dusts do not tend to flocculate except under electrostatic forces; they do not diffuse in air but settle under the influence of gravity.

[1] Numbers in parentheses refer to references given on pages 424–425.

Fumes: Solid particles generated by condensation from the gaseous state, generally after volatilization from molten metals, etc., and often accompanied by a chemical reaction such as oxidation. Fumes flocculate and sometimes coalesce.

Mists: Suspended liquid droplets generated by condensation from the gaseous to the liquid state or by breaking up a liquid into a dispersed state, such as by splashing, foaming, and atomizing.

Gases: Normally formless fluids which occupy the space of enclosure and which can be changed to the liquid or solid state only by the combined effect of increased pressure and decreased temperature. Gases diffuse.

Vapors: The gaseous form of substances which are normally in the solid or liquid state and which can be changed to these states either by increasing the pressure or decreasing the temperature alone. Vapors diffuse.

Dusts are of signal importance in view of the large number of persons exposed to dusts, and also because such exposure has been associated with serious damage to the human system. Dusts of a siliceous (4) nature may produce damage to the respiratory system, while dusts of the heavy-metal group such as lead, (5) mercury, (6) and manganese (7) may cause systemic poisoning. Other dusts such as carbon, calcium carbonate, and aluminum oxide are relatively nontoxic, but even for the relatively harmless contaminants, which are classified as nuisances, there is a degree of atmospheric contamination that cannot be exceeded without adversely affecting the health of exposed workers. *All atmospheric contaminants should be considered potentially hazardous until proved harmless.*

The toxic fumes of industrial significance are those arising from the oxidation of vapors from metals heated to high temperatures. The most common of these fumes which have been found to cause poisoning include lead oxides, arsenic oxides, and cadmium oxides.

The gas hazards of industry are also of significance, and the fatalities from gas poisoning still constitute a major problem in industry. Gases occur as raw materials, as products, and as agents of manufacture. The inhalation of many gases foreign to pure air may be said to be almost universal. Among the gases common to everyday industrial life are carbon monoxide, sulfur dioxide, hydrogen sulfide, hydrogen cyanide, ammonia, and the gases employed for refrigerating purposes, such as methyl and ethyl chloride. It must also be remembered that relatively nontoxic gases such as carbon dioxide may displace oxygen and cause death by asphyxiation.

A knowledge of the physiology of respiration is essential in the study of the effects of toxic gases on the human system. (8) From the viewpoint of their effect on respiration, gases may be

classified as asphyxiants, irritants, volatile drugs, and druglike substances.

Biological health hazards include the infections, such as anthrax, tuberculosis, typhoid fever, pneumonia, and other respiratory diseases. Illness may result from the handling of contaminated materials such as skins or wool infected with anthrax; from a lowering of resistance to infection by arduous duties and extreme changes in temperature, exemplified by the high incidence of pneumonia in certain occupations in the steel industry; or by direct exposure to active cases of disease required by the nature of one's duties. The investigations of air bacteriology and studies of the methods of controlling bacterial contamination of the air have been extensive in recent years. (9)

The *physical health hazards* are extremely important in industry, since in this category are the accidents caused by machinery and other environmental conditions, and the physiological effects of excessive humidity, heat and cold, defective illumination, noise, repeated motion, shock, and abnormal atmospheric pressures.

Study of the workroom environment

The preliminary survey. The first task before an engineer in the field of industrial hygiene is the determination of the nature and scope of the problem. In the absence of occupational disease and sickness statistics, health hazards may be ascertained by a preliminary survey of the working environment. This preliminary survey will serve as a guide for the more detailed studies which may be necessary to determine any relationship between that environment and its effect on the health of the worker. This preliminary or reconnaissance survey includes the sanitary appraisal and the occupational analysis of the workroom and the employees. (10)

Such an investigation shows the extent to which certain facilities are furnished the workers with reference to accident prevention, first aid, medical and nursing services, engineering control of occupational diseases, and the availability of records of accidents and illness. It also indicates the specific occupational exposure to various health hazards, whether of a chemical, biological, or physical nature, and gives an idea of the control measures now in practice for each hazard.

In order to assist the engineer in the conduct of such preliminary surveys, certain forms are recommended. (11) Figures 1 and 2 illustrate recent modifications of these forms. Form *A* lists data of a general nature, including items of a sanitary char-

FORM A

NATIONAL DEFENSE INDUSTRIAL HYGIÈNE SURVEY
INDUSTRIAL HEALTH SERVICE DATA

Page..........of..........
Surveyed by..............

Name of Plant..Industry Code and No................Date................
County..........................City..........................State....................Location........................
Plant Owner............................Address..Number of employees
Plant Official..........................Title..Male................
Female................
Products manufactured or service..Total................

Safety Provisions	Medical Provisions		Benefits and Records	Sanitation	
Safety director Full-time.......... Part-time.......... None..........	Hospital Company.......... Contract.......... None..........	Physician Full-time.......... Part-time.......... On call.......... None..........	Sick benefit organization Yes.......... No..........	.......Public supply ....Fountain ....Individual cup ....Common cup ....Other	Drinking
Shop committee Yes.......... No..........	First-aid room Yes.......... No..........	Nurse Full-time.......... Part-time.......... None.......... P.H.......... R.N.......... Other..........	Sickness records Yes.......... No.......... Waiting period.......... Days..........	.......Sink ....Other ....Cold water ....Hot water ....Soap ....Common towel ....Other towel ....Shower	Washing
Insurance company service Yes.......... No..........	First-aid kit Yes.......... No..........		Occupational disease coverage Yes.......... No..........		
Other.......... Yes.......... No..........	Trained first-aid worker Yes.......... No..........				
Remarks	Physical examination Pre-employment Yes.......... No..........	Periodical Yes.......... No..........	Accident records Yes.......... No..........	.......Flush ....Pit privy ....Other	Toilet
Overtime	Remarks		Remarks	.......Separate lunchroom ....Individual locker	

Fig. 1—Form for recording health service data.

FORM C

NATIONAL DEFENSE INDUSTRIAL HYGIENE SURVEY
WORKROOM SURVEY DATA

Page.......... ..of............
Name of Plant..Industry Code and No....................
Department..........................D/W..........S/W............Workroom No..........................
Informant's Name..........................Surveyed by..........................Date..........................

Occupation	Number of persons			Nature of job	Raw materials and byproducts	Exposure code	Control Measures										Remarks
	M	F	T				Pos. Ven	Neg. Ven	Loc. Exh.	Enc. Proc.	Wet Meth.	Gas Mask	Respirat.	Pres. Hel.	Pro. Clo.	Other	
Total brought forward																	
Total																	

Fig. 2—Form for recording workroom survey data.

acter, in order to provide information on housekeeping, provision of personal services—such as cloak rooms, locker rooms, showers, and toilets—and information on various medical, nursing, and safety services. Form *C* (Figure 2) deals primarily with the individual occupation, providing space for the designation of the occupation, the number of persons involved, the nature of the work performed, and the raw materials and products associated with each occupation. Space is also provided for noting control measures associated with each exposure and individual occupation.

After filling out the two inspection forms for each workroom in an entire plant, and making additional notes on items which may not be provided for in the forms under discussion, a detailed analysis of the data contained in the forms is in order. This analysis enables one to furnish a complete picture of the hygienic conditions in each of the workrooms studied and in the plant as a whole.

Once the important health hazards have been located by means of the preliminary survey, the next step in the program is the *quantitative* evaluation of the working environment in its relation to the health of the worker.

The detailed survey. In order to determine a worker's exposure to materials or conditions incident to his employment, one must have precise data on such exposure. In some cases the difference between a hazardous and a nonhazardous condition may depend upon whether or not the worker is exposed continuously to concentrations of materials bordering on the threshold limit of toxicity (the maximum permissible concentration). For example, in the case of exposure to lead oxides, where the maximum permissible concentration is 0.15 milligrams of lead per cubic meter of air, it is very important to know whether the worker is inhaling lead in concentrations slightly above or below this limit. Frequently a difference of a milligram in the day's intake of lead by an exposed worker may spell the difference between a safe or an unsafe condition.

Detailed appraisals of exposure enable one to determine the extent of a hazard. This is accomplished by determining, by precise methods, the occupational exposures to the toxic materials or conditions under consideration. Today, the engineer and chemist have at their disposal delicate instruments and methods of analysis unprecedented in the history of industrial hygiene, and the knowledge concerning such matters is increasing from day to day. It is no longer necessary in industrial hygiene to guess as to actual exposures. While space does not permit a detailed dis-

TABLE 21

TOXIC LIMITS OF VARIOUS SUBSTANCES

Substance	*Maximum Allowable Concentration**
Acrolein	1 p.p.m.
Acrylonitrile	20 p.p.m.**
Ammonia	100 p.p.m.
Amyl acetate	400 p.p.m.**
Aniline	5 p.p.m.
Arsine	1 p.p.m.
Benzene (Benzol)	100 p.p.m.
Butyl acetate	400 p.p.m.**
Butyl alcohol	200 p.p.m.**
Carbon dioxide	5000 p.p.m.
Carbon disulfide	20 p.p.m.
Carbon monoxide	100 p.p.m.
Carbon tetrachloride	100 p.p.m.
Dichlorobenzene	75 p.p.m.
Dimethylaniline	similar to aniline
Ethylene dichloride	100 p.p.m.
Gasoline (Petroleum)	1000 p.p.m.
Hydrogen chloride	10 p.p.m.
Hydrogen cyanide	20 p.p.m.
Hydrogen fluoride	3 p.p.m.
Hydrogen sulfide	20 p.p.m.
Methyl alcohol	200 p.p.m.
Monochlorobenzene	75 p.p.m.
Mononitrotoluene	similar to nitrobenzene
Nitrobenzene	5 p.p.m.
Nitrogen oxides	40 p.p.m.
Petroleum naphthas	1000 p.p.m.
Phosgene	1 p.p.m.
Phosphine	1 p.p.m.
Sulfur dioxide	10 p.p.m.
Tetrachloroethane	10 p.p.m.
Tetrachloroethylene	200 p.p.m.
Toluene (Toluol)	200 p.p.m.
Trichloroethylene	200 p.p.m.
Turpentine	200 p.p.m.
Xylene (Xylol)	200 p.p.m.
Barium peroxide	0.5 mg./m.^{3}***
Cadmium	0.1 mg./m.^{3}
Chromic acid	0.1 mg./m.^{3}
Lead	0.15 mg./m.^{3}
Mercury	0.1 mg./m.^{3}
Dinitrotoluene	similar to TNT
Tetryl	1.5 mg./m.^{3}***
TNT	1.5 mg./m.^{3}
Zinc oxides	15.0 mg./m.^{3}
Silica (SiO_2) (free or uncombined)	5 m.p.p.c.f.

* The maximum allowable concentration for the various substances listed are the values most widely accepted today; these are based on an eight-hour daily exposure.

** These values have not been definitely established but they are included to serve as a guide.

*** No specific information available, but believed to present no health hazard at this concentration.

Note: p.p.m. = Parts of substance per million parts of air by volume.
mg./m.^{3} = Milligrams of substance per cubic meter of air.
m.p.p.c.f. = Millions of particles of substance per cubic foot of air.

cussion of the methods for the sampling and analysis of atmospheric contaminants, these methods are available in the reports of the American Public Health Association Committee on Standard Methods for the Examination of Air. (12)

The relative toxicity of many materials is unknown at present, and different materials may exert different physiological effects, thereby preventing their comparison. The United States Public Health Service (1) has found the list of maximum allowable concentrations shown in Table 21 to be useful as a guide in the selection of less toxic substitutes for materials used in industrial processes. Although many of these suggested maximum allowable concentrations do not have official standing, they are the most widely accepted values at this time.

Extent of hazard. Where maximum allowable concentrations have been established, the detailed engineering study is a direct indication of the existence or absence of an industrial health hazard. By a proper evaluation of the chemical composition of the atmospheric contaminants, the concentration of these contaminants in the air, and the average exposure of the worker each day, we are able to predict the injury that will be caused. For certain materials, as silica dust, which have a slow but cumulative adverse effect, the above-mentioned data applied to the worker's occupational history enable us to estimate the amount of damage that has already been done.

The method of calculating average dust exposures, either for the occupation or for the total occupational exposure of the individual worker was illustrated in a report on Soft Coal Miner's Health and Working Environment. (13) Table 22 gives the method employed in obtaining the average dust concentration for the operation of undercutter operator. It is a weighted average in that the activities associated with different dust concentrations and the time spent in each activity that is a part of the occupation are given consideration. In this way, it is possible to determine the activity or activities that contribute the most dust. In this instance, undercutting and shearing constitute 67 per cent of the undercutter operator's dust exposure. Control of these activities would appreciably diminish the dust exposure of this particular occupation.

The method employed in calculating the weighted average dust exposure of an individual worker for his entire experience in the coal-mining industry is shown in Table 23. The occupations engaged in were taken from the occupational history of the worker. Weight was given to the number of days of work per week as well as to the number of years spent in each occupation.

TABLE 22

CALCULATING THE AVERAGE DUST EXPOSURE OF UNDERCUTTER OPERATORS IN A BITUMINOUS COAL MINE

Activity	Number of samples	Number of hours in activity (a)	Average dust count, millions of particles per cubic foot (b)	Million particle hours per cubic foot (a × b)
Man-trip in and out	3	1	6.0	6.0
Unloading, setting up undercutter, repairing and changing teeth	4	1½	50.0	75.0
Undercutting and shearing	15	4	44.9	179.6
Loading and moving undercutter	3	1½	5.7	8.5
Total	25	8		269.1

$$\frac{\textit{269.1} \text{ million particle-hours per cubic foot}}{8 \text{ hours}} = 33.6 \text{ million particles per cubic foot}$$

= weighted average dust exposure.

TABLE 23

CALCULATING THE WEIGHTED AVERAGE DUST EXPOSURE OF A TYPICAL BITUMINOUS COAL MINE WORKER

Occupation	Number of years in occupation (a)	Weighted dust concentration millions of particles per cubic foot (b)	Millions of particle-years per cubic foot of air (per 5-day week) (a × b)	Days per week worked (c)	Millions of particle-years per cubic foot $(a \times b) \times \frac{c}{5}$
Trackman	2	10.4	20.8	4	16.6
Machine loader	1	9.3	9.3	4	7.4
Mule driver	4	6.7	26.8	5	26.8
Hoistman	8	3.8	11.4	5	11.4
Tipple operator	6	17.0	102.0	3	61.2
Total	21	....	.....	..	123.4

$$\frac{\textit{123.4} \text{ millions of particle-years per cubic foot}}{21 \text{ years}} = 5.9 \text{ millions of particles per cubic}$$

foot = weighted average dust exposure.

Correlation with clinical data. When maximum permissible concentrations of an atmospheric contaminant are not known, the detailed engineering study will serve a second purpose if clinical investigations are made concurrently with environmental studies. The findings on occupational exposure may indicate the permissible amounts of the toxic materials that may be tolerated with safety.

The relationship between lead dust exposure, years of exposure, and the percentage of exposed workers with diagnosed early plumbism (5) is shown in Figure 3.

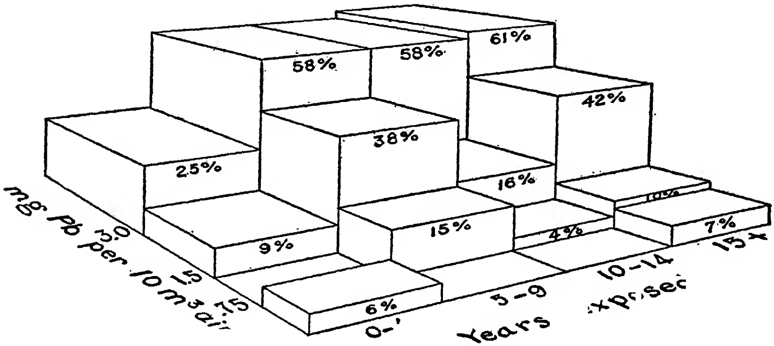


Fig. 3—The percentages of storage battery workers in each of 16 exposure groups diagnosed as cases of early plumbism are represented by the heights of blocks. Thus, of the workers exposed more than 15 years to atmospheric lead concentrations in excess of 3 mg. Pb per 10 M.³ of air, 61 per cent were found to have early plumbism.

From these and other data it was concluded that 1.5 milligrams of lead dust per 10 cubic meters of air (or 0.15 mg./m.³), except for very prolonged exposure, is the limit of safety under the conditions encountered in these studies. Important findings of this type are of great value to engineers, since they give them a basis upon which to develop protective devices and control measures such as exhaust ventilation, respiratory protection, and good housekeeping.

Evaluation of control measures. The third purpose served by the detailed engineering study deals with the control of health hazards. By such studies one can determine the efficiency of any devices that may have been introduced for the control or elimination of those hazards. The study of the efficiency of various methods employed for the control of industrial health hazards will be treated in more detail in the next section. It is desired, however, in closing this portion of the discussion, to point out that the engineering problems in industrial hygiene are constantly increasing in number, especially now when new chemicals and processes are being introduced into our war industries. Our knowledge of the action of these substances on the body is constantly being augmented by toxicologists and by field studies of the type described. It is the engineer's task, once this knowl-

edge is available, to devise ways and means for controlling these injurious materials and conditions.

The control of industrial health hazards

The control of industrial health hazards is also a joint function of the medical and engineering departments. The *physician* and his co-workers recognize the existence of diseases due to the workroom environment and exercise medical supervision and initiate studies designed to eliminate dangerous conditions. The *engineer* and his co-workers determine the extent of the hazard, and, armed with knowledge of the toxicity of the materials involved, are able to develop methods and equipment for the control of the hazard. They should also call the physician's attention to new materials and operations that may be hazardous.

There are no set rules for the mechanical protection to be instituted in an attempt to control an industrial health hazard. The specific conditions encountered in each plant determine the type of protection to be employed. There are, however, five principal methods for minimization of an industrial exposure: (a) substitution of a nontoxic material for a toxic one; (b) complete enclosure of the harmful process; (c) local exhaust ventilation; (d) wet methods in the case of certain specific processes; and (e) respiratory protection. In many instances it may be necessary to employ a combination of the above methods in the control of a single exposure, or to combine one of these methods with emergency methods such as (a) isolation of the harmful process; (b) general room ventilation, or (c) decreasing the work period to decrease the total exposure.

Substitution. The only method for completely eliminating all possibilities of exposure to a toxic material is to substitute a nontoxic material for the toxic one. This is practicable in some instances where the toxic substance is not an essential ingredient of the finished product, or when a nontoxic substitute will give a substitute product of equivalent value. Where the desired finished product is itself toxic, substitution is of course impossible. This is illustrated by such processes as the manufacture of trinitrotoluene (TNT) and other war explosives.

One example of a successful substitution is the use of steel grit or an artificial abrasive in place of sand in the sandblasting process, in operations where it is not necessary to use quartz sand. Table 24 clearly indicates the lowering in the dust concentration when a steel abrasive was employed instead of sand in an abrasive blasting room. (14)

TABLE 24

REDUCTION IN CONCENTRATION AND QUARTZ CONTENT OF DUST IN SANDBLAST ROOMS BY THE SUBSTITUTION OF STEEL FOR SAND ABRASIVE

Type of abrasive	Average dust concentration in millions of particles per cu. ft.	Percentage of quartz
Sand	969	42–98
Steel	155	3

Another example of substitution is the elimination of mercury nitrate as a carroting solution applied to rabbit fur utilized for the production of felt hats. (6) For more than a hundred years certain operations in the preparation of hatters' fur and in the subsequent manufacture of the hats had entailed exposure to mercury vapor and dust with accompanying mercurialism among the workers. The hatting industry itself recently developed and adopted nonmercurial carroting solutions, and mercurialism should be completely eradicated from the industry soon. Even when a nontoxic substitute cannot be found for a toxic one, conditions can frequently be improved by providing a substitute which is relatively less harmful. Substitutions of this type would include the replacement of benzol by toluol as a paint solvent, the use of trichlorethylene instead of carbon tetrachloride in degreasing operations, and the use of zinc pigments instead of lead in paints.

TABLE 25

DUST CONCENTRATIONS FOR SANDBLAST INSTALLATIONS REGARDED BY MANUFACTURERS AS "IDEAL" IN COMPARISON WITH OTHER EQUIPMENT

Compared with other equipment	Average dust count in millions of particles per cubic foot		
	Barrels	Tables	Cabinets
Ideal	1.7	0.2	1.9
Other	29.0	22.0	38.0

Enclosure. Where a toxic material must be used, the possibilities of its becoming an atmospheric contaminant may be minimized by completely enclosing the industrial process. An additional factor of safety can be secured by operating the enclosed process under slight negative pressure. This type of protection is well illustrated in the case of dust exposure by the modern enclosed sandblast barrel used for cleaning small objects. Table 25

contrasts the practical elimination of dust exposure in certain sandblasting operations that were well enclosed with those that did not offer this kind of protection.

Local exhaust ventilation. Local exhaust ventilation is the most frequently used method of control of certain workroom conditions that are harmful to health. It is one of the methods that aims to prevent atmospheric contamination by collecting and removing dusts, fumes, vapors, and gases at their point of generation. There are few industries in which local exhaust ventilation is not used in some form, and in some large industries the complete system may be as extensive as the production equipment. The design of the ventilation system should be considered in the design of new buildings so that the system will form part of the completed structure. The design and installation of a ventilation system in a building where the installation of equipment has been completed without previous consideration of control measures handicaps the ventilation engineer, increases the cost of the control system, and will usually increase operating costs.

A local exhaust ventilation system consists essentially of four parts: (a) hoods or partial enclosures, (b) air ducts, (c) a collector, and (d) an exhauster.

So much depends on the correct design and construction of hoods and exhaust systems that they should be laid out by well-trained engineers and maintained with great care. In recent years a tremendous amount of basic engineering data on this type of control has accumulated. Data pertaining to the quantity of air that must be removed in order to control hazards or nuisances are available (15) as well as data on the necessary entrance velocities to hoods having certain size and shape characteristics. However, a thorough knowledge of the physical laws governing the flow of air into suction openings and of the physical and chemical properties of the various atmospheric contaminants is essential before attempting to design an efficient hood, that is, a hood that collects the contaminant effectively with a minimum of air removal and without interference in the operation of the tool or process. Minimum air velocities, across the source of generation, for the capture of materials released in certain manufacturing processes vary from as low as 75 to 100 feet per minute where materials are released without creating noticeable air movement, as in the evaporation of solvents from degreasing or plating tanks, to as high as 2,000 or more f.p.m. where materials are released with great force, as in grinding or abrasive blasting.

Air ducts or exhaust pipes convey the contaminated air to the collector and exhauster. The size of these pipes is governed by

the amount of air that must be moved and by the minimum and maximum controlling velocities. The minimum velocity must be above the velocity that will permit settling of solid particles in the duct system, while the maximum velocity should be below the velocity that will cause excessive abrasion on the pipes or excessive noise. Economic savings secured by reduction in velocity to conserve power and abrasion will be partially counterbalanced by increased size of piping and increased cleaning requirements. Alden (15) recommends minimum conveying velocities varying from as low as 2,000 f.p.m. for vapors and gases to as high as 5,000 f.p.m. or more for large particles of heavy materials such as lead dust.

All exhaust ventilation systems do not require collectors or air purifiers, but these should be used where the collected material is valuable, where the abrasive or corrosive qualities of the material will injure the exhauster, or where the unpurified air will produce a nuisance or a health hazard. If air purifiers are not used, the discharge stacks of the exhaust system should be located at a point that will prevent contaminated air from reentering any occupied buildings. Types of air purifiers or collectors commonly used include cloth filters, electrostatic precipitators, air-washers, and cyclones. It is always advisable to locate the collector upstream from the exhauster to prevent abrasion, explosions, or corrosion.

The exhauster is the source of motion of the air into the hoods and through the ductwork and collector. While fans are the most common type of exhauster, air-, steam-, or water-operated ejectors have been found to be very practical, particularly in plants manufacturing explosives. Propellor-type fans may prove satisfactory in low-velocity systems, but for the usual high-resistance, high-velocity system, centrifugal-type fans are necessary.

Wet methods. The use of water or other suitable liquid in operations producing dust or fumes, or both, will under some circumstances control the particulate matter. Even in the case of some gases which are readily soluble in water, wet methods give satisfactory control. In practice, this method is limited to a small number of dust-producing operations such as grinding, drilling, ore loading, and sweeping. Experience in the mining industry has shown that dust concentrations of over 560 million particles per cubic foot associated with dry drilling operations can be reduced to 30 million particles per cubic foot or below by use of wet drilling methods. Unfortunately, finely divided particulate matter is difficult to wet, and we also find that wetted dust particles may be readily redispersed into the atmosphere as the collecting liquid

dries. Wet methods when used properly produce worth-while results, but it is usually necessary to employ them in conjunction with general exhaust ventilation.

Respiratory protection. It is the consensus that, in the control of exposures to air-borne toxic materials, primary consideration should be given to procedures for preventing excessive contamination of the air in the breathing zone. However, situations occur where these procedures are not applicable, practical, or effective. For these situations, personal respiratory protection will be required, either as a primary means of protection or as an adjunct to other preventive procedures. Respiratory protective devices have been greatly improved in recent years, and at present the United States Bureau of Mines is approving such devices after rigid testing. (16)

In selecting respiratory protective devices, care should be taken to insure that each device is designed and approved for use against the specific toxic material encountered and under the conditions in which it is encountered. No gas mask, chemical cartridge type respirator, or mechanical filter type respirator will sustain life in an atmosphere deficient in oxygen, and even supplied-air respirators or hose masks should not be used in such locations unless the worker is protected by a life-line operated by another worker located in a safe place.

Respiratory protective devices and protective clothing have been discussed in a previous chapter from both a health and a safety viewpoint. The use of goggles, aprons, boots, rubber gloves, and the newer types of protective clothing made from plastics as well as the use of protective ointments are all important in the prevention of dermatoses, which are among the most important industrial diseases. (17, 18)

Other control measures. Isolation of a toxic process or operation will minimize the number of workers exposed but will not protect the operator of the process involved. The use of sandblasting rooms for cleaning large castings is an example of this method. While the exposure of other workers in the foundry is reduced, the sandblaster's exposure is actually increased. However, this method, combined with the use of a supplied-air sandblast helmet to protect the operator, gives satisfactory results.

The principle of diluting toxic contaminants below the maximum permissible limit by *general room ventilation* may be a valuable adjunct to other methods of control; it proves adequate as the sole method of control only if the degree of air contamination is low, and preferably if the contaminant is released at an appreciable distance from the workers' breathing zone so that the

contaminant is suitably diluted or dispersed before it is inhaled. For specific operations where the operator is stationed near by, or for processes where the sources of contamination are well defined, local exhaust ventilation is more practical and economical than dilution ventilation. Obviously, the above statements apply only to general ventilation as a means of controlling atmospheric contamination, and not to the minimum requirements of good ventilation for occupied spaces.

Reducing the period of exposure to a toxic substance will reduce the average daily exposure; but it is not economically practical and can be considered only as a last resort. It is not recommended where positive control measures can be applied, but it should be considered in case of emergency repairs or infrequent operations, or as a protection against adverse physical conditions, as illustrated by the shortening of hours of work by some industries for furnace repair men, arsenic flue cleaners, and caisson workers.

Maintenance of a control program

The purchasing and installing of good, carefully designed control equipment is only the first step in an effective control program. Even the best equipment will become inefficient in a comparatively short time unless it is maintained in good working condition. In fact, poorly maintained control equipment may be worse than no control equipment at all, since it gives a false sense of security and prevents the adoption of efficient control methods. Maintenance is a coöperative duty of the employer and the employee. Management should provide trained personnel to inspect, clean, lubricate, and repair all control equipment routinely. The worker should learn to handle equipment properly and to report to management all signs of wear or failure. In order to secure these results, the worker must be informed as to why the equipment is necessary and how it should be used. This education should not, as a rule, be left entirely to the foreman but should be part of the general safety education program.

Maintenance of control equipment must be supplemented by "good housekeeping" to produce safe working conditions. This is particularly important with respect to the control of dusts and fumes. Particulate matter settles out of the air on floors, ledges, machinery, and other objects. The starting of a machine or a sudden air current will dislodge and redisperse this material into the air, resulting in needlessly increased atmospheric contamination. Good housecleaning should include frequent and routine

cleaning of all exposed surfaces. This should be done by means of suitable vacuum cleaning systems or by wet sweeping methods. Dry sweeping is poor practice. Blowing the dust off machines and structural surfaces should be prohibited, since it is merely a means of recontaminating the air.

Effect of the war on industrial hygiene

War production has multiplied the factors affecting industrial diseases and accidents and has greatly complicated the normal problem of industrial health. Specific difficulties are as varied as the enormously diversified war industries themselves, but the national problem presents four broad conditions which exist to a greater or lesser extent in all localities. These are:

1. Health problems arising in the community environment.
2. The physical composition of the war labor force as compared to peacetime labor supply.
3. Hazards that are found in the working environment.
4. The shortage of trained personnel in the various professions concerned with health conservation in industry.

In this discussion we have considered only the problems of the working environment. The reader is already aware of the increase in accidents. There are also indications that occupational diseases are on the increase. Some of the factors contributing to this picture are employment of new workers, relaxed safety measures, and poor working conditions. In a zealous attempt to obtain peak production, management and workers alike have been likely to overlook matters relating to health, or not even to recognize them until an unfortunate incident occurs. In a misplaced effort to save time, vigilance in safety and health may be relaxed. With machines operating 24 hours a day, maintenance is likely to be less efficient. In addition to these factors, many substances and processes unfamiliar to the worker have been and will continue to be introduced. Some of these materials are new to industry, and a large number of materials have new applications.

Nevertheless, by far the largest portion of our new problems result from exposures to toxic materials which we have known for a long time, but which are now being employed in strange usage, or are being used by industries which are taking on new work with which they have been unfamiliar in the past.

All these rapid developments make it imperative that practical measures be taken to determine the hazards involved and the control measures to be applied *no*

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